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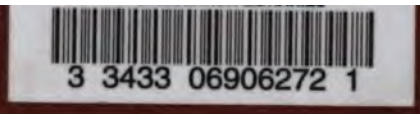
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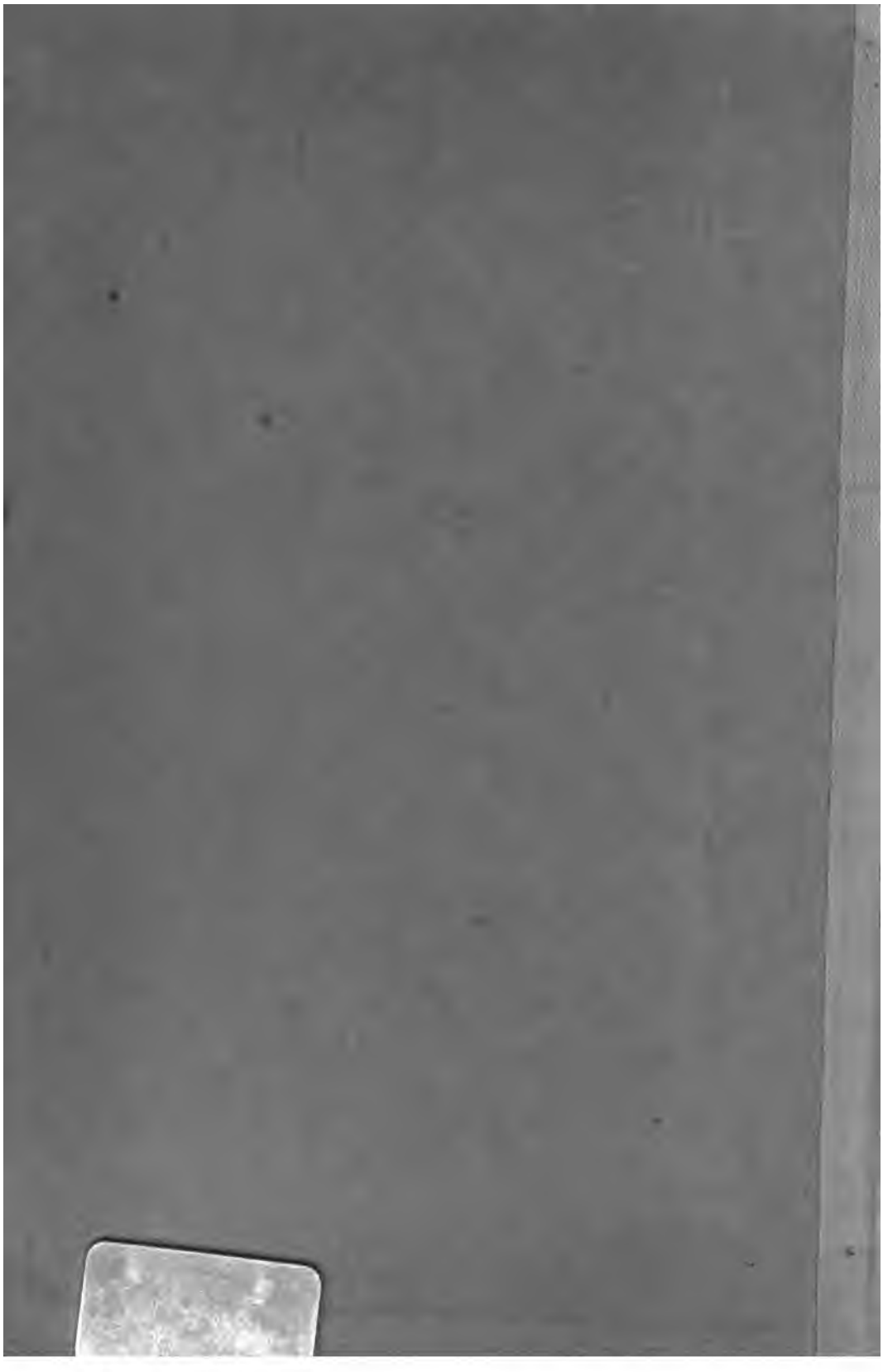

# THE MINERAL INDUSTRY

ITS

## STATISTICS, TECHNOLOGY AND TRADE

DURING

## 1912

*FOUNDED BY RICHARD P. ROTHWELL*

EDITED BY

CHARLES OF
*Mining Engineer*

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# THE STATE GEOLOGICAL SURVEYS

Of the 46 States of the Union, 35 have organized geological surveys, these comprising nearly all of the States in which the mining industry is important. The organization of a geological survey in Massachusetts is under consideration. Certain States which have no geological survey have officials who give attention to the mining industry. Thus, California has a State mineralogist, while Idaho has a State mine inspector who collects statistics of mineral production. The States having organized geological surveys, together with the names and addresses of the respective State geologists, as of Jan. 1, 1913, are given in the following list:

STATE GEOLOGISTS.

| State. | Name and Address. | State. | Name and Address. |
|---|---|---|---|
| Alabama | Eugene A. Smith, Uuiversity. | New Jersey | H. B. Kümmel, Trenton. |
| Arkansas | N. F. Drake, Fayetteville. | New York | John M. Clarke, Albany. |
| Connecticut | Wm. N. Rice, Hartford. | N. Carolina | Joseph Hyde Pratt, Chapel Hill. |
| Colorado | R. D. George, Director, Boulder. | N. Dakota | A. G. Leonard, Grand Forks. |
| Florida | E. H. Sellards, Tallahassee. | Ohio | J. A. Bownocker, Columbus. |
| Georgia | S. W. McCallie, Atlanta. | Oklahoma | D. W. Ohern, Norman. |
| Illinois | F. W. DeWolf, Director, Urbana | Pennsylvania | H. C. Demming, Harrisburg. |
| Indiana | Edward Barratt, Indianapolis. | S. Carolina | Earle C. Sloan, Charleston. |
| Iowa | Geo.F.Kay, Director, Des Moines | S. Dakota | E. C. Perisho, Vermillion. |
| Kansas | Erasmus Haworth, Lawrence. | Tennessee | A. H. Purdue, Nashville. |
| Kentucky | J. B. Hoenig, Frankfort. | Texas | W. B. Phillips, Austin. |
| Maine* | C. Vey Holman, Burnswick. | Vermont | G. H. Perkins, Burlington. |
| Maryland | William Bullock Clark, Baltimore. | Virginia | Thos. L. Watson, Charlottesville. |
| Michigan | R. C. Allen, Lansing. | Washington | Henry Landes, Seattle. |
| Mississippi | E. N. Lowe, Jackson. | West Virginia | I. C. White, Morgantown. |
| Missouri | H. A. Buehler, Rolla. | Wisconsin | W. O. Hotchkiss, Madison. |
| Nebraska | E. H. Barbour, Lincoln. | Wyoming | C. E. Jamison, Cheyenne. |

STATE MINE INSPECTORS, COMMISSIONERS, ETC.

| State. | Name and Address. |
|---|---|
| Alabama | C. H. Nesbit, Chief Mine Inspector, Birmingham. |
| Arizona | G. H. Bolin, State Mine Inspector, Phoenix. |
| Arkansas | G. B. Tucker, Commissioner, Bureau of Mines, Manufactures and Agriculture, Little Rock. |
| California | F. McN. Hamilton, State Mineralogist, San Francisco. |
| Colorado | T. R. Henahen, Commissioner, Denver. |
| | James Dalrymple, Coal Mine Inspector, Denver. |
| Idaho | R. N. Bell, State Mine Inspector, Boise. |
| Indiana | Elliot R. Hooton, Chief Mine Inspector, Indianapolis. |
| Kansas | Frank Gilday, State Mine Inspector. |
| Kentucky | C. J. Norwood, Chief Mine Inspector, Lexington. |
| Maryland | Wm. Walters, State Mine Inspector, Midland. |
| Minnesota | F. A. Wildes, State Mine Inspector, Hibbing. |
| Missouri | George Bartholomaeus, Secretary, Bureau of Mines and Mines Inspection, Jefferson City. |
| Montana | J. B. McDermott, State Coal Mine Inspector, Helena. |
| New Mexico | Rees H. Beddow, Mine Inspector Gallup, N. M. |
| Ohio | J. G. Davies, Chief Inspector of Mines, Columbus. |
| Oklahoma | Ed. Boyle, Chief Inspector, Guthrie, Okla. |
| Oregon | H. M. Parks, Director, Bureau of Mines, Corvallis. |
| Pennsylvania | James Roderick, Chief, Department of Mines, Harrisburg. |
| South Dakota | R. L. Dougherty, State Mine Inspector, Lead. |
| Tennessee | Geo. E. Sylvester, Chief Mine Inspector, Nashville. |
| West Virginia | John Laing, Chief, Department of Mines, Charleston. |

*Officially abolished by the Legislature in 1911.

# VALUE OF FOREIGN COINS

ESTIMATE BY DIRECTOR OF THE MINT, 1913.

| Country. | Standard. | Monetary Unit. | Value in Terms of U.S. Gold Dollar. | Coins. |
|---|---|---|---|---|
| Argentine Republic. | Gold... | Peso | $0.965 | Gold: argentine ($4.824) and ½ argentine. Silver: peso and divisions. |
| Austria-Hungary.. | Gold... | Crown | .203 | Gold: 10 and 20 crowns. Silver, 1 and 5 crowns. |
| Belgium | Gold... | Franc | .193 | Gold: 10 and 20 francs. Silver: 5 francs. |
| Bolivia | Gold... | Boliviano | .389 | Silver: boliviano and divisions. |
| Brasil | Gold... | Milreis | .546 | Gold: 5, 10 and 20 milreis. Silver: ½, 1 and 2 milreis. |
| British Possessions, N.A. | Gold... | Dollar | 1.000 | ..... |
| Central Amer. States—Costa Rica. | Gold... | Colon | .465 | Gold: 2, 5, 10 and 20 colons ($9.307) Silver: 5, 10, 25 and 50 centimos. |
| British Honduras. | Gold... | Dollar | 1.000 | ..... |
| Guatemala... Honduras.... Nicaragua.... Salvador..... | Silver . | Peso | .400 | Silver: peso and divisions. |
| Chile | Gold... | Peso | .365 | Gold: escudo ($1.825), doubloon ($3.650), and condor ($7.300). Silver: peso and divisions. |
| China | Silver | Tael.. Amoy | .715 | ..... |
| | | Tael.. Canton | .713 | ..... |
| | | Tael.. Cheefoo | .683 | ..... |
| | | Tael.. Chin Kiang | .699 | ..... |
| | | Tael.. Fuchau | .661 | ..... |
| | | Tael.. Haikwan (customs). | .727 | ..... |
| | | Tael.. Hankow | .669 | ..... |
| | | Tael.. Kisochow | .692 | ..... |
| | | Tael.. Nankin | .707 | ..... |
| | | Tael.. Niuchwang | .670 | ..... |
| | | Tael.. Ningpo | .687 | ..... |
| | | Tael.. Peking | .697 | ..... |
| | | Tael.. Shanghai | .653 | ..... |
| | | Tael.. Swatow | .660 | ..... |
| | | Tael.. Takau | .719 | ..... |
| | | Tael.. Tientsin | .692 | ..... |
| | | Dollar Hongkong | .470 | ..... |
| | | Dollar British | .470 | ..... |
| | | Dollar Mexican | .473 | ..... |
| Colombia | Gold... | Dollar | 1.000 | Gold: condor ($9.647) and double condor. Silver: peso. |
| Denmark | Gold... | Crown | .268 | Gold: 10 and 20 crowns. |
| Ecuador | Gold... | Sucre | .487 | Gold: 10 sucres ($4.8665). Silver: sucre and divisions. |
| Egypt | Gold... | Pound (100 piasters) | 4.943 | Gold: pound (100 piasters), 5, 10, 20 and 50 piasters. Silver: 1, 2, 5, 10 and 20 piasters. |
| Finland | Gold... | Mark | .193 | Gold: 20 marks ($3.859), 10 marks ($1.93). |
| France | Gold... | Franc | .193 | Gold: 5, 10, 20, 50 and 100 francs. Silver 5 francs. |
| German Empire.... | Gold... | Mark | .238 | Gold: 5, 10 and 20 marks. |
| Great Britain..... | Gold... | Pound sterling | 4.866⅔ | Gold: sovereign (pound sterling) and ½ sovereign. |
| Greece | Gold... | Drachma | .193 | Gold: 5, 10, 20, 50 and 100 drachmas. Silver: 5 drachmas. |
| Haiti | Gold... | Gourde | .965 | Gold: 1, 2, 5 and 10 gourdes. Silver: gourde and divisions. |
| India (British).... | Gold... | Pound sterling* | 4.866⅔ | Gold: sovereign (pound sterling). Silver: rupee and divisions. |
| Italy | Gold... | Lira | .193 | Gold: 5, 10, 20, 50 and 100 lire. Silver: 5 lire. |
| Japan | Gold... | Yen | .498 | Gold: 5, 10 and 20 yen. Silver: 10, 20 and 50 sen. |

NOTE.—The coins of silver-standard countries are valued by their pure silver contents, at the average market price of silver for the three months preceding January 1, 1913.

*The sovereign is the standard coin of India, but the rupee ($0.324⅓) is the current coin, valued at 15 to the sovereign.

| Country. | Standard. | Monetary Unit. | Value in Terms of U.S. Gold Dollar. | Coins. |
|---|---|---|---|---|
| Liberia | Gold... | Dollar | 1.000 | |
| Mexico | Gold... | Peso† | .498 | Gold: 5 and 10 pesos. Silver: dollar‡ (or peso) and divisions. |
| Netherlands | Gold... | Florin | .402 | Gold: 10 florins. Silver: 2½, 1 florin, and divisions. |
| Newfoundland | Gold... | Dollar | 1.014 | Gold: 2 dollars ($2.027). |
| Norway | Gold... | Crown | .268 | Gold: 10 and 20 crowns. |
| Panama | Gold... | Balboa | 1.000 | Gold: 1, 2½, 5, 10 and 20 balboas. Silver: peso and divisions. |
| Persia | Silver. | Kran‡‡ | .0875 | Gold: ½, 1, and 2 tomans ($3.409). Silver: ¼, ½, 1, 2 and 5 krans. |
| Peru | Gold... | Libra | 4.86⅔ | Gold: ½ and 1 libra. Silver: sol and divisions. |
| Philippine Islands | Gold... | Peso | .500 | Silver peso: 10, 20 and 50 centavos. |
| Portugal | Gold... | Milreis | 1.080 | Gold: 1, 2, 5 and 10 milreis. |
| Roumania | Gold... | Leu | .193 | |
| Russia | Gold... | Ruble | .515 | Gold: 5, 7½, 10 and 15 rubles. Silver: 5, 10, 15, 20, 25, 50 and 100 copecks. |
| Servia | Gold... | Dinar | 1.93 | |
| Siam | Gold... | Tical | .3708 | |
| Spain | Gold... | Peseta | .193 | Gold: 25 pesetas. Silver: 5 pesetas. |
| Straits Settlement | Gold... | Pound sterling§ | 4.86⅔ | Gold: sovereign (pound sterling). Silver: dollar and divisions. |
| Sweden | Gold... | Crown | .268 | Gold: 10 and 20 crowns. |
| Switzerland | Gold... | Franc | .193 | Gold: 5, 10, 20, 50 and 100 francs. Silver: 5 francs. |
| Turkey | Gold... | Piaster | .044 | Gold: 25, 50, 100, 250 and 500 piasters. |
| Uruguay | Gold... | Peso | 1.034 | Gold: peso. Silver: peso and divisions. |
| Venezuela | Gold... | Bolivar | .193 | Gold: 5, 10, 20, 50 and 100 bolivars. 5 bolivars. |

† Seventy-five centigrams fine gold.
‡ Value in Mexico, $0.498.
§ The current coin of the Straits Settlements is the silver dollar issued on Government account, and which has been given tentative value of $0.567758⅓.
‡‡ The Gold Kran $0.1704.

### Russian Weights and Measures.

| | | |
|---|---|---|
| 1 Dolia | = .6857 grs. troy | = (for gold at £3 13s per oz.) 1 1/4d. |
| 1 Zolotnik | = 65.8329 grs. troy | = (for gold at £3 13s per oz.) 10s. |
| 1 Funt | = 13.1665 oz. troy | = (for gold at £3 13s per oz.) £48. |
| 1 Pood | = 526.6632 oz. troy | = (for gold at £3 13s per oz.) £1922. |
| 1 Pood | = 36.11 lb. av. | |
| 62.025 Poods | = 1 ton (2240 lb.). | |
| 1 Arschin | = 2 ft. 4 in. | |
| 1 Sashen | = 7 ft. | |
| 1 Deciatine | = 2400 sq. sashens | = 2.7 acres. |
| 1 Verst | = 500 sashens | = 1166 yd. or 2/3 mile approximately. |

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# INTRODUCTION

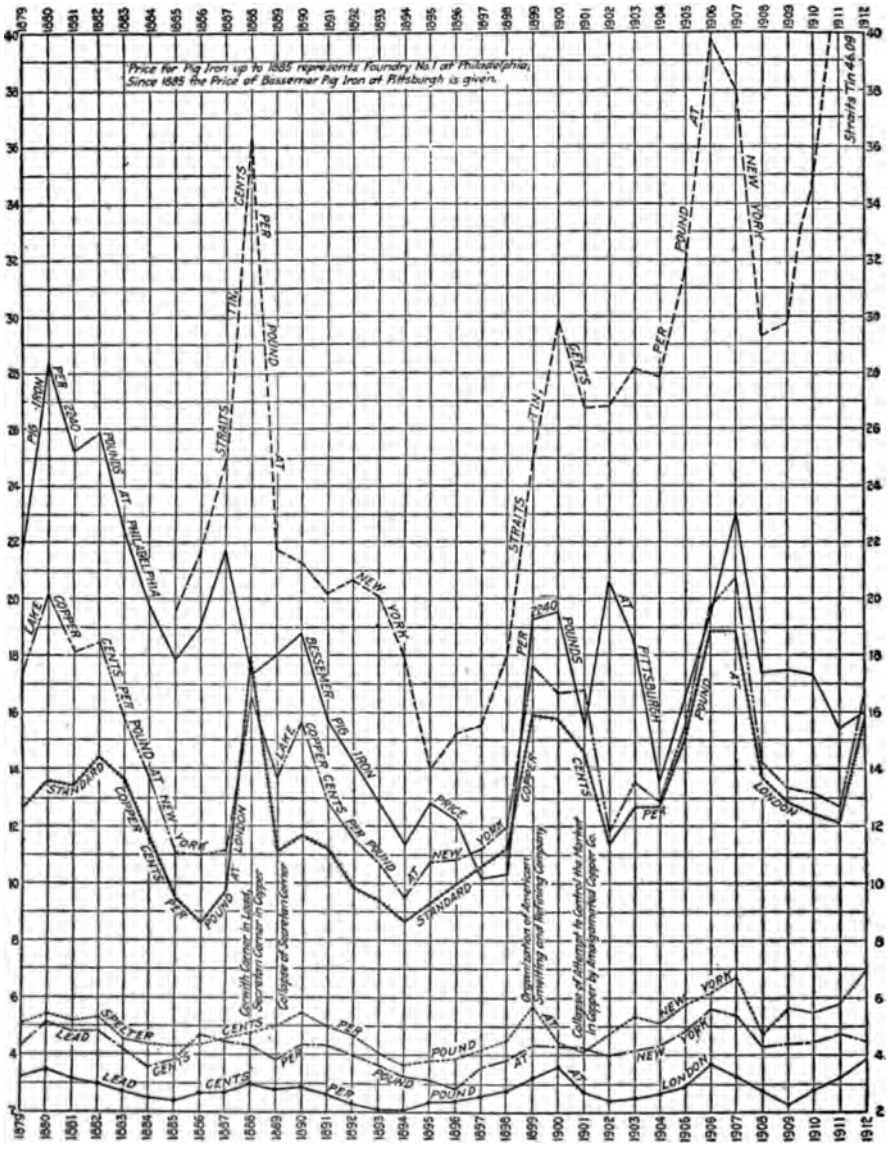
The aim in compiling this volume for the calendar year 1912 has been, as in previous years, to record the progress of the mining and metallurgical industries. As usual, many industries relating to manufactured substances are included, especially in cases in which such products are replacing more or less the natural or mined products. The source of raw materials for all these industries is the mine or quarry, but recent progress in science and its application is rapid and the industries and processes of manufacture are reviewed whenever possible. The substances are arranged alphabetically in the first part of the volume. Where separate articles do not treat the manufactured product, any reference will be found by consulting the index. Special articles of interest to the mining man follow in the last part of the book. Finally the statistical tables for the chief countries, the chief mineral productions, mineral exports and imports are found at the end of the text.

Contributions from specialists make up a large part of the MINERAL INDUSTRY. It is intended that the subjects not treated by specialists are compiled from year to year so as to constitute a reliable record condensed and abstracted from technical literature. The method of selection has been the same as in former years. In some cases a critical review is possible, but in the main a simple record of changes, improvements or progress has been compiled.

For many of the statistics relating to the mineral production in the United States in 1912 and previous years, we are indebted to the *U. S. Geol. Surv.*; for the production of gold and silver in the United States, to George E. Roberts, Director of the Mint; and for the statistics of American imports and exports, to A. H. Baldwin, Chief of the Buraeu of Foreign and Domestic Commerce. Acknowledgement is due also to various State Geological Surveys and Statistical Bureaus for facts incorporated in this volume. Generally in individual cases footnotes or mention in the text give proper credit for information, but this acknowledgment stands for any unintentional oversight. Special acknowledgment is hereby given to those heads of departments in various countries that have courteously coöperated in furnishing reports, in many cases prior to the publication of their official reports. We have indicated these in footnotes or otherwise as "officially reported," by the respective governments.

The statistics of copper, lead, zinc, and iron are compiled largely

from data published in the *Eng. and Min. Journ.* Statistics as to coal and coke have been taken from *Coal Age.* Many of the reviews of the


Price for Pig Iron up to 1885 represents Foundry No.1 at Philadelphia;
Since 1885 the Price of Bessemer Pig Iron at Pittsburgh is given.
Straits Tin 46.09
PIG IRON PER 2240 POUNDS AT PHILADELPHIA
TIN STRAITS CENTS PER POUND AT NEW YORK
TIN STRAITS PER 2240 POUNDS AT NEW YORK
AT PITTSBURGH
AT LONDON
LAKE COPPER CENTS PER POUND AT NEW YORK
STANDARD COPPER CENTS PER POUND AT LONDON
BESSEMER PIG IRON
LAKE COPPER CENTS PER POUND AT NEW YORK
STANDARD COPPER PRICE
LEAD
SPELTER
CENTS PER POUND AT NEW YORK
CENTS PER POUND AT LONDON
Growth of Copper Interests
Organization of American Smelting and Refining Company
Collapse of attempt to Control the Market in Copper by Amalgamated Copper Co.
Co-operation of Secondary Interests

important districts have been adapted from articles in the numerous mining journals and, as heretofore in each case, due credit has been given,

so that by following up these references more detailed information is available. The various articles have been abstracted and condensed in accordance with the importance of the subjects they treat, but generally it is impossible to reproduce many excellent articles on account of lack of space, and these, therefore, are largely represented by bibliographies which cover the most important literature that has appeared during the year.

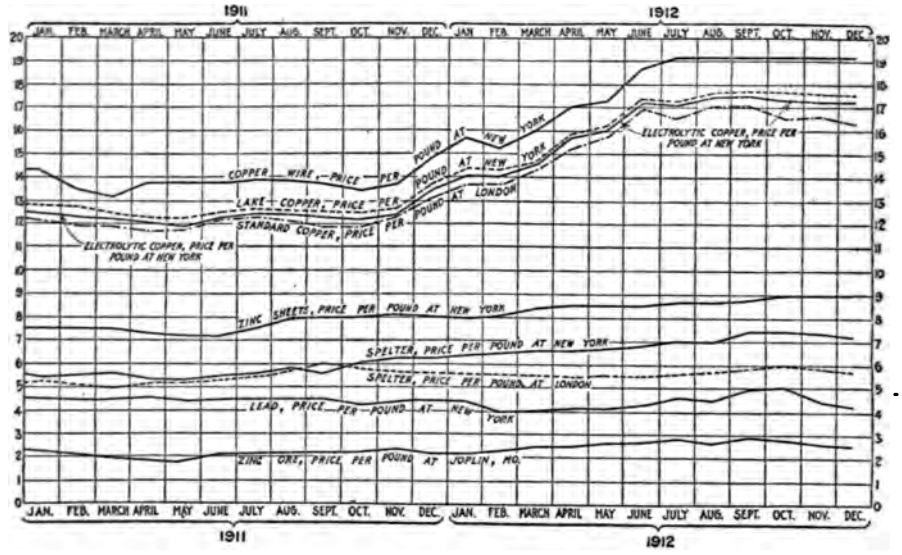
Statistics have been collected with the usual care, and corrections of previous figures made whenever possible. In this Vol. XXI, therefore, will be found the available figures accepted in the light of the latest reports and it is consequently *important to use the last* volume of MINERAL INDUSTRY. The last volume repeats figures for previous years for comparison, but in general does not attempt to retain figures older than, say, 10 years. On the other hand, a few statistics of minor importance are published only in the particular volume covering the year in question.

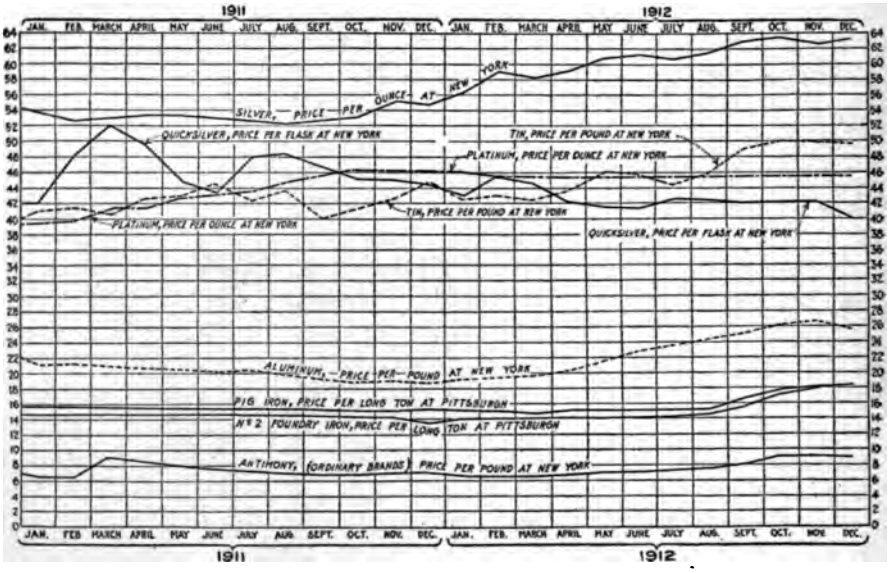
The degree of accuracy characterizing the volumes of MINERAL INDUSTRY, it is believed, will serve commercial purposes. Statistics for the recent calendar year cannot be complete in all cases, owing to the fact that they necessarily have been collected in less than 6 months. For the year 1912, for example, a few of the foreign governments have announced a delay and have adopted the policy for this year at least of not issuing provisional figures. The final figures will be published after this volume is printed, but technical and business men will find figures promptly published and of reasonable accuracy of greater value than those statistics a year or two late, although the latter may have their final accuracy.

Many difficulties and much expense are met with in gathering accurate data for this volume from producers. Coöperation of the great majority is hereby gratefully acknowledged. Some very important companies, however, owing to a policy of secrecy, refuse to give information, although such confidential figures are of use only in making up aggregates and would not be disclosed. To these difficulties are added the unavoidable errors in reporting explicit figures, due to confusion of weights and measures of value. The amount of labor in ferretting out discrepancies and eliminating errors has not been spared, but estimates based on available facts are used in compiling some of the data. Figures of this nature are stated as provisional or as estimates.

In the introductory tables relating to the United States productions of mineral ores and metals, etc., as in previous volumes, all substances are not covered, so that the total value of mineral production is not ascertainable, but the individual figures serve for comparison. As in the text we cannot hope to treat in less than 1000 pages all of the extensive industries,

some very important ones such as clay, pottery, building stone, limestone, etc., have had to be omitted. Further details and statistics of these


1911
1912
JAN. FEB. MARCH APRIL MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.
COPPER WIRE PRICE PER POUND AT NEW YORK
LAKE COPPER PRICE PER POUND AT NEW YORK
STANDARD COPPER PRICE PER POUND AT LONDON
ELECTROLYTIC COPPER, PRICE PER POUND AT NEW YORK
ELECTROLYTIC COPPER, PRICE PER POUND AT NEW YORK
ZINC SHEETS, PRICE PER POUND AT NEW YORK
SPELTER, PRICE PER POUND AT NEW YORK
SPELTER, PRICE PER POUND AT LONDON
LEAD, PRICE PER POUND AT NEW YORK
ZINC ORE, PRICE PER POUND AT JOPLIN, MO.


1911
1912
JAN. FEB. MARCH APRIL MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.
SILVER, PRICE PER OUNCE AT NEW YORK
QUICKSILVER, PRICE PER FLASK AT NEW YORK
PLATINUM, PRICE PER OUNCE AT NEW YORK
TIN, PRICE PER POUND AT NEW YORK
TIN, PRICE PER POUND AT NEW YORK
PLATINUM, PRICE PER OUNCE AT NEW YORK
QUICKSILVER, PRICE PER FLASK AT NEW YORK
ALUMINUM, PRICE PER POUND AT NEW YORK
PIG IRON, PRICE PER LONG TON AT PITTSBURGH
No 2 FOUNDRY IRON, PRICE PER LONG TON AT PITTSBURGH
ANTIMONY, (ORDINARY BRANDS) PRICE PER POUND AT NEW YORK

industries can be found in the Mineral Resources of the United States Geological Survey.

PRODUCTION OF METALS IN THE UNITED STATES. (x)

| Products. | Measures. | 1911. | | 1912. | |
|---|---|---|---|---|---|
| | | Quantity. | Value. | Quantity. | Value. |
| Aluminum | lb. | 28,600,000 | $5,720,000 | 40,000,000 | $9,200,000 |
| Antimony | lb. | 3,566,000 | 296,500 | 4,096,000 | 341,500 |
| Copper | lb. | 1,083,856,371 | 134,398,190 | 1,241,762,508 | 198,682,000 |
| Ferromanganese (q) | Lg. T. | 184,718 | 7,245,950 | 221,724 | 11,607,250 |
| Gold fine | Troy oz. | 4,687,053 | 96,890,000 | 4,437,561 | 91,685,134 |
| Iron, pig | Lg. T. | 23,464,829 | 346,106,230 | 29,505,213 | 448,184,185 |
| Lead | Sh. T. | 400,958 | 35,445,000 | 410,000 | 36,655,000 |
| Nickel | lb. | (e)300,000 | 150,000 | 200,000 | 100,000 |
| Platinum | Troy oz. | 929 | 40,058 | 1,000 | 45,550 |
| Quicksilver (o) | Flasks. | 21,500 | 989,254 | 25,147 | 1,067,700 |
| Silver, fine | Troy oz. | 60,399,400 | 32,192,883 | 63,369,903 | 37,920,899 |
| Sodium | Sh. T. | (e)2,000 | 1,000,000 | (e)2,000 | 1,000,000 |
| Tin | Sh. T. | (e)5,500 | 3,751,000 | (e)5,500 | 4,000,000 |
| Zinc | Sh. T. | 295,836 | 34,021,000 | 348,638 | 47,415,000 |

Additional details will be found under the respective captions farther on in this volume. (e) Estimated. (o) Flasks of 75 lb. (q) Includes spiegeleisen, although the value is given as for ferromanganese. (v) Recovered from scrap metal. (w) Statistics not available. (x) Includes only metal produced from domestic ores except in case of zinc and tin.

PRODUCTION OF ORES AND MINERALS IN THE UNITED STATES.

| Products. | Measures. | 1911. | | 1912. | |
|---|---|---|---|---|---|
| | | Quantity. | Value. | Quantity. | Value. |
| Antimony ore | Sh. T. | 50 | $2,000 | *Nil.* | ..... |
| Asbestos | Sh. T. | 7,604 | 119,935 | (u)4,403 | $87,959 |
| Asphaltum | Sh. T. | (u)364,266 | 3,991,109 | 449,510 | 4,620,731 |
| Barytes | Sh. T. | 41,057 | 152,732 | 46,472 | 209,275 |
| Bauxite | Lg. T. | 155,618 | 757,860 | (u)159,865 | 768,932 |
| Borax | Sh. T. | (u)53,330 | 1,569,151 | 42,315 | 1,127,813 |
| Chrome ore | Lg. T. | 935 | 14,197 | 1,220 | 10,310 |
| Coal, anthracite | Sh. T. | 90,537,566 | 175,110,815 | 84,478,527 | 178,959,605 |
| Coal, bituminous | Sh. T. | 400,349,454 | 455,958,842 | 445,091,864 | 504,424,434 |
| Emery | Sh. T. | 659 | 6,778 | 992 | 6,652 |
| Feldspar | Sh. T. | (u)92,700 | 579,008 | (u)86,572 | 520,562 |
| Fluorspar | Sh. T. | 47,000 | 270,000 | 123,387 | 876,337 |
| Fuller's earth | Sh. T. | (u)40,697 | 383,124 | 32,715 | 305,522 |
| Garnet | Sh. T. | 4,285 | 121,759 | (u)4,182 | 137,800 |
| Graphite, amorphous | Sh. T. | 1,223 | 32,415 | 673 | 19,344 |
| Graphite, crystalline | lb. | 4,790,000 | 256,050 | 3,543,771 | 187,689 |
| Gypsum | Sh. T. | 2,323,970 | 6,462,035 | (u)2,500,757 | 6,563,908 |
| Iron ore | Lg. T. | 41,878,190 | 75,380,700 | 59,485,477 | 101,125,000 |
| Limestone flux | Lg. T. | (u)16,126,650 | 7,987,208 | (w) | ..... |
| Magnesite | Sh. T. | (u)9,375 | 75,000 | 11,000 | 110,000 |
| Manganese ore (d) | Lg. T. | (u)2,457 | 24,586 | (u)1,664 | 15,723 |
| Mica sheet | lb. | 1,887,201 | 310,254 | 845,483 | 211,000 |
| Mica scrap | Sh. T. | 3,512 | 45,550 | 3,226 | 49,073 |
| Molybdenum ore | Sh. T. | *Nil.* | ..... | *Nil.* | ..... |
| Monazite | lb. | 3,561 | 427 | 1,272 | 159 |
| Petroleum, crude | Bbl. (i) | 213,381,884 | 117,360,000 | 220,516,266 | 176,413,000 |
| Phosphate rock | Lg. T. | 3,216,993 | 12,394,140 | 3,166,032 | 12,600,670 |
| Pumice | Sh. T. | (u)21,689 | 88,399 | (u)27,146 | 86,687 |
| Pyrite | Lg. T. | 299,904 | 1,150,597 | 337,243 | 1,276,908 |
| Salt | Bbl. (k) | 31,183,968 | 8,345,692 | 33,324,808 | 9,402,772 |
| Sand, glass | Sh. T. | 1,538,666 | 1,543,733 | 1,465,386 | 1,430,471 |
| Sand, molding | Sh. T. | 3,376,717 | 2,132,469 | 4,484,953 | 2,718,398 |
| Sulphur | Lg. T. | 206,200 | 4,540,000 | 787,663 | 15,753,000 |
| Talc, ordinary ground and soapstone | Sh. T. | 81,521 | 1,032,732 | 69,270 | 1,042,000 |
| Talc, fibrous | Sh. T. | (e)62,500 | 562,500 | 70,000 | 665,000 |
| Tin ore | Sh. T. | *Nil.* | ..... | 175 | 70,000 |
| Tungsten | Sh. T. | 1,293 | 500,000 | 1,290 | 580,500 |
| Zinc ore | Sh. T. | 669,305 | 26,770,000 | 805,109 | 32,204,000 |

Additional details will be found under the respective captions farther on in this volume. (d) Does not include manganiferous iron ore. (e) Estimated. (i) Barrels of 42 gal. (k) Includes salt used in manufacture of alkali; the barrel of salt weighs 280 lb. (u) Figures reported by the United States Geological Survey. (v) Includes graphite shale. (w) Statistics not yet available.

PRODUCTION OF SECONDARY MINERALS AND CHEMICALS IN THE UNITED STATES.

| Products. | Measures. | 1911. | | 1912. | |
|---|---|---|---|---|---|
| | | Quantity. | Value. | Quantity. | Value. |
| Alundum | lb. | 11,116,000 | $666,960 | 13,266,486 | $795,989 |
| Ammonium sulphate | Sh.T. | 127,000 | 7,216,360 | 165,000 | 10,890,000 |
| Arsenic | lb. | 6,162,000 | 154,050 | 5,852,000 | 204,820 |
| Bromine | lb. | 901,000 | 225,500 | 1,085,000 | 270,000 |
| Carborundum | lb. | 10,376,620 | 622,597 | 12,042,550 | 722,553 |
| Cement, natural hydraulic | Bbl.(g) | 926,091 | 378,533 | 821,231 | 367,222 |
| Cement, portland | Bbl.(h) | 78,528,637 | 66,248,817 | 82,438,096 | 67,022,172 |
| Cement, puzzolan | Bbl.(i) | 93,230 | 77,786 | 91,864 | 77,363 |
| Coke | Sh.T. | 33,349,754 | 79,040,624 | 43,544,351 | 114,477,500 |
| Copper sulphate (c) | lb. | 33,454,000 | 1,472,000 | 39,480,788 | 2,171,000 |
| Copperas | Sh.T. | 35,501 | 390,500 | 41,713 | 420,000 |
| Crushed steel | lb. | 800,000 | 56,000 | 700,000 | 49,000 |
| Graphite, artificial | lb. | 10,144,000 | 664,000 | 12,896,347 | 830,193 |
| Lead, white, in oil | Sh.T. | (u)206,778 | 14,699,339 | 120,591 | 16,041,100 |
| Lead, white, dry | Sh.T. | 25,834 | 2,693,902 | 26,242 | 2,642,361 |
| Lead, red | Sh.T. | 19,540 | 2,345,320 | 21,120 | 2,571,702 |
| Lead, orange mineral | Sh.T. | 766 | 119,370 | 545 | 88,245 |
| Litharge | Sh.T. | 25,190 | 2,773,196 | 29,111 | 3,194,194 |
| Lime | Sh. T. | (u)3,392,915 | 13,689,054 | 3,529,462 | 13,970,114 |
| Mineral, wool | Sh.T. | 7,514 | 65,500 | 4,200 | 40,000 |

Additional details will be found under the respective captions farther on in this volume. (c) Does not include sulphate made from metallic copper. (e) Estimated. (g) Barrels of 265 lb. (h) Barrels of 380 lb. (i) Barrels of 330 lb. (u) Figures reported by the United States Geological Survey. (w) Statistics not yet available.

The growth of the mineral industry is well illustrated from statistics showing during the last 5 years that the products of mining and metallurgical industries have increased in value more than a dozen fold. During the same period the value of the world's agricultural products increased only twice, whereas manufactures increased about fourfold.

As to tonnage, the United States produces one-third the mineral products, Great Britain another third, and the remaining nations one-third

The value for the United States of the annual mineral products, however, is far greater than that of any other country. As in other industries, opportunities for economies have been taken advantage of and often what were formerly wastes from mining and metallurgy are now recovered.

The principal mineral production of the United States in order of values are the fuels—coal and petroleum. Of the metal products iron is next in order, and then copper, with gold third. In the order of tonnage the fuels exceed the tonnage of any other mineral product, iron being second; but the fuels exceed in weight at least five times the weight of all other products combined.

Coal is the chief fuel or source of heat energy, and this industry now furnishes 1,104,000,000 tons each year the world over. In plant growths there is available apparently solar energy in excess of the present consumption, and long before the coal supply is exhausted methods for using the r source of heat will be worked out that are even now feasible where portation of other fuel is too expensive.

The heating value of the petroleum in the world at the present rate of production per year is that of 45,000,000 tons of coal, or about 1/15 of the annual coal production. In view of the extended uses of petroleum and its efficiency for power purposes, the exhaustion of petroleum reserves is relatively nearer than that of coal, the chief fuel source. The introduction of petroleum fuel in metallurgical plants is a fact, but whether this is a temporary matter or not depends on the local cost, which is likely to fluctuate.

In 1912 for the first time copper was produced in the world amounting to more than 1,000,000 tons. In the United States the production of copper, iron, lead and zinc were in each case the greatest on record. All these being coincident with good prices, the mining industry was especially favored and showed a marked prosperity as compared with 1911.

The metal markets, always an indication of prosperity, had a good year in 1912. Both prices and outputs in the United States were high and toward the end of the year demands were such that prompt deliveries of some metals were not possible.

American mining companies that publicly announce their dividends paid $67,832,442 in 1912, compared with $56,971,791 in 1911. Canadian and Mexican companies paid $21,130,597 in 1912 and $15,934,911 in 1911. American metallurgical companies paid $99,599,094 in 1912 and $94,-044,899 in 1911.

What profits were made by other mining and metallurgical companies cannot be estimated. Neither is the amount paid out for mining ventures not bringing returns known for a single year. More money has been sunk in recent years in gold mining in the world than the value of the gold recovered. According to the Census Bureau, the producing gold and silver mines in the United States numbered 3715, as compared with non-producers numbering 8544.

# CHRONOLOGY OF MINING IN 1912

Jan. 2.—Picher Lead Co. secured control of the lead smelteries at Webb City, Mo., and Galena, Kansas.

Jan. 6.—Mason Valley smeltery at Thompson, Nev., was blown in.—Organization of Inspiration Consolidated Mining Company.

Jan. 9.—Six men were killed and two injured by an explosion of dynamite in the Parrish mine, near Plymouth, Penn.

Jan. 11.—Lehigh Valley R. R. announced plan to separate the railroad from its coal properties.—An anti-Japanese riot at Hayden, Arizona.

Jan. 15.—Converters at Braden mines in Chile were started.—Utah Copper Co. placed the seventh section of the Arthur mill in commission.

Jan. 16.—Two men were killed by a falling timber in Kingdon shaft of Old Dominion company.

Jan. 17.—Four men were killed in a mine of the Central City Coal & Iron Co. at Central City, Kentucky.

Jan. 18.—Note of British miners was announced as 445,801 for a strike on March 1, and 115,921 against.

Jan. 20.—Fire at loading station of the Daly West and Ontario mines in Utah, caused loss of about $20,000 and necessitated temporary shutdown of the Daly West.

Jan. 21.—Five men were reported killed or injured in a dust explosion at No. 4 mine of Kemmerer Coal Co., at Kemmerer, Wyoming.

Jan. 31.—Fire destroyed surface works at the W. Y. O. D. mine, near Grass Valley, Calif.; $30,000 loss.

Feb. 7.—Sixty-eight miners, temporarily imprisoned in Bunker Hill mine, California, by a falling skip which blocked the shaft.

Feb. 12.—An accident in a coal mine at Antonienhütte, Prussia, reported to have killed 27 men.

Feb. 15.—Smelting resumed by the Consolidated Arizona Smelting Co., at Humboldt, Arizona.

Feb. 19.—Announcement of initial dividend of $1,000,000 by the Bonanza copper mine, Alaska.

Feb. 23.—Eight men killed and 20 injured in a fire at No. 5 mine of the Western Coal & Mining Co., at Lehigh, Okla.—Sixth section of the Miami mill was placed in operation giving the mill its full capacity.

Feb. 26.—The U. S. District Court at Trenton, N. J., decided that

the Butters filter was not an infringement of the Moore filter, in the suit of the Moore Filter Co. against the Tonapah-Belmont Development Company.

Feb. 28.—Ray Consolidated stockholders voted to increase stock to 1,600,000 shares, to absorb the Ray Central company.

Feb. 29.—British coal-miners' strike was inaugurated, before official time, by a walkout of about 800,000 men.—First furnace of the lead smeltery of the International Smelting & Refining Co. blown in.

March 1.—Dissolution of the Butte Coalition company, its property passing to the Anaconda company.

March 2.—President Taft issued a proclamation respecting the troubles in Mexico, advising American residents to keep out of them.

March 4.—The Supreme Court announced its decision to review the action of the Ninth U. S. Circuit Court of Appeals, which denied relief to the farmers of Deer Lodge Valley from the fumes of the smeltery at Anaconda, Montana.

March 7.—Fire partially destroyed the Mogul cyanide plant in the Black Hills, South Dakota; $75,000 damage, covered by insurance.—An explosion in the mine of the Diamond Vale Collieries Co., at Merritt, B. C., killed seven men.

March 11.—The McIntyre 10-stamp mill, at Porcupine, commenced operation, becoming the first regular producer of bullion in this district.

March 14.—A snowslide killed four men at the Black Bear Mine, in the San Juan region, Colorado.

March 15.—The Arizona Commercial Copper Co. went into the hands of a receiver, in default of interest on a $1,000,000 bond issue.

March 16.—An explosion was reported to have killed 45 men in the Italianka coal mine, in Russia.

March 18.—The smeltery of the American Smelting & Refining Co., at Durango, Colo., was blown in after a shut-down since November.

March 20.—An explosion in the Chant No. 2 mine of the Sans Bois Coal Co., at McCurtain, Okla., killed 74 men.

March 26.—An explosion at the Jed Coal & Coke Co.'s Jed mine, 2 miles from Welch, W. Va., killed 81 men.

March 31.—The Dome mill at Porcupine started.

April 1.—Miners in Butte decided not to strike by vote of 4460 to 1121—A gold bar of 160 oz. was deposited from the McIntyre mill in a Porcupine bank, being the first commercial product from the Porcupine district.—Miami Copper Co. declared initial dividend.—Inauguration of anthracite coal miners' strike in the United States.

April 2.—Stockholders of Chino Copper Co. voted to increase capital stock by 100,000 shares.

April 6.—Leaders instructed the striking British coal miners to return to work.

April 10.—Sampling plant of the Nipissing company destroyed by fire.

April 18.—Trouble at the Lena Goldfields workings at Irkutsk, Russia, resulted in the killing of 107, and wounding of 80 workmen by troops.

April 20.—Roasting furnaces put in operation at new Hayden plant of A. S. & R. Co.

April 21.—An explosion of gas in the Coil coal mine at Madisonville, Ky., killed five men, all that were in the mine.

April 25.—John D. Ryan, president of the Amalgamated company, announced that the company would spend $2,500,000 on reconstruction of the Great Falls smeltery.

April 27.—Organization of convention of European aluminum producers.

April 30.—An explosion reported to have entombed 283 miners in the Hokkaido Coal Co.'s mine at Yubari, Japan.

May 1.—Giroux company began ore shipments to the Steptoe Valley works.—Strike at the Murray plant of the American Smelting & Refining Co. at Murray, Utah.

May 6.—The Eureka & Palisade R. R. resumed operation.

May 10.—First lot of electrically smelted pig iron shipped from California to Salt Lake City.

May 13.—Strike at Baltimore copper refinery.—Cave-in at Norrie iron mine in Michigan killed seven men.

May 15.—First blister copper made at Hayden plant of American Smelting & Refining Co.

May 16.—Government filed suit against the Aluminum Co. of America, to restrain it from illegal practices.

May 23.—Fire destroyed the stamp mill of the San Miguel Mining Co., Telluride district, Colorado.

June 1.—United States Smelting, Refining & Mining Co. secured control of the Consolidated Fuel Co.'s lands in Utah, comprising about 5000 acres.—Trial run on Giroux ore begun at Steptoe concentrator.

June 2.—A 7000-bbl. gusher of the Pacific Crude Oil Co. in California caught fire and burned six days before extinguished.—Announcement of formation of the Canadian Mining & Exploration Co., Ltd., with a capital of $5,000,000.

June 5-6.—Fighting between revolutionists and the employees at the property of the Cuba Copper Co. near Santiago de Cuba.

June 10.—Operators in the Globe-Miami district, Arizona, raised wages.

June 13.—The Interstate Commerce Commission ruled that interstate pipe lines are common carriers.—The United States Court at Wilmington, Del., issued a final decree ordering the dissolution of the so-called powder trust and a division of the business among three companies.—Award of $400,000 damages to the Smuggler-Union company, in Colorado, in its suit against the Liberty Bell mine for trespass.

June 15.—The Hollinger mill at Porcupine started.

June 18.—Settlement of the strike at the refinery of the American Smelting & Refining Co., at Perth Amboy, N. J.

June 19.—An explosion in the Hastings mine of the Victor-American Fuel Co., in Colorado, killed 12 men and injured one.

July 1.—Butte miners voted to accept wage proposition of Anaconda company to pay $4 per day on the basis of 17-c. copper, to be effective June 1.

July 4.—An explosion of firedamp in the Osterfield colliery near Oberhausen, Germany, killed 14 miners.

July 7.—An explosion of dynamite killed 10 and injured two men loading holes in the Eureka pit of the Nevada Consolidated.—At the Braden copper mine, in Chile, 30 men were killed by a dynamite explosion underground.

July 9.—An explosion killed 88 men in the Cadeby colliery in Yorkshire, England, the day after that mine had been visited by King George V.

July 11.—An explosion in the Panama colliery of the Ben Franklin Coal Co. at Moundsville, W. Va., killed eight men.—The Arizona Commercial mine was purchased by Charles Smith at public sale for $1,000,000.

July 16.—Six miners were killed and three were seriously injured in an explosion at the Gayton colliery of the Old Dominion Development Co., about 20 miles from Richmond, Va.

July 18.—A cloudburst in the Seven Troughs district, Nevada, drowned 13 persons and did much damage in the towns of Mazuma and Seven Troughs.

July 21.—Standard mill of the Amalgamated Asbestos Co. at Thetford, Que., was destroyed by fire.

July 24.—The new mill of the Tonopah-Belmont company commenced operation.—A cloudburst swept away a dam, drowning 13 men in the Superba No. 2 colliery near Uniontown, Penn.

July 25.—The smeltery of the Santa Fé Gold & Copper Co. in the San Pedro district, New Mexico, was blown in.

July 26.—Three men were burned in the shaft of the No. 3 colliery of the Monon Coal Co., near Linton, Indiana.

July 31.—Announcement of the consolidation of the Alaska-Perseverance, Oxford and Sheep Creek properties near Juneau, Alaska, as the Alaska-Gastineau Mining Co.

Aug. 1.—An explosion of gas occurred in the colliery of the Washington-Wheatland Coal Co., at Wheatland, Ind., injuring five men, two fatally.

Aug. 2.—A premature explosion on the seventeenth level of the "D" shaft of the Newport mine, at Ironwood, Mich., killed one miner and injured another.

Aug. 3.—Festivities celebrating the centenary of the Krupp iron works at Essen.

Aug. 8.—An explosion in the Lothringen colliery near Gerthe, Germany, killed 114 and injured 16 men.

Aug. 12.—Announcement of the organization of the Alaska Gold Mines Co., to acquire control of the Alaska-Gastineau Mining Co., owning large, low-grade gold deposits near Juneau, Alaska.

Aug. 13.—Explosion in the Abernant colliery, 28 miles from Birmingham, Ala., killed 37 men.

Aug. 27.—Four miners killed by blackdamp in the Frontier colliery, at Linden, Wis.

Aug. 30.—A wooden platform collapsed at a colliery at Gelsenkirchen, in Prussia, allowing six men to fall down the shaft, five of whom were killed.

Sept. 3.—Explosion of firedamp in the Clarence colliery, near Bruay, Département du Nord, France, killed 61 men, including some of the rescuers who entered the colliery after the initial explosion.

Sept. 4.—Heavy rains flooded the Ruddy mine, at Biwabik, Minn., causing caving at the saft and entombing three men.

Sept. 5.—One man was killed and five slightly injured in an overwinding accident at the Bunker Hill & Sullivan mine, at Kellogg, Idaho.

Sept. 10.—Smelting plant of Granby Mining & Smelting Co., at Granby, Mo., destroyed by fire.

Sept. 14.—The first sod turned for the East & West Australian railway at Port Augusta.

Sept. 15.—Mexican rebels captured the town of El Tigre, Sonora, Mexico, and robbed the Lucky Tiger-Combination Gold Mining Co. of bullion and merchandise.

Sept. 16.—One man killed and two injured by an explosion of gas in the Wharton Coal Co., colliery, at Coral, Penn., a few hours after the mine had been declared non-gaseous by official inspectors.

Sept. 18.—Miners at Bingham, Utah, went out on strike upon

refusal of the companies to advance wages 50 cents per shift and recognize the union.

Oct. 1.—Wages increased 25 cents per day at Mason Valley mines and smeltery in Nevada.—Nevada Consolidated increased miners' wages 25 cents per day.

Oct. 2.—Miners in Ely copper district, Nevada, went out on strike for increase in wages of 50 cents per day and recognition of the Western Federation of Miners.

Oct. 3.—International Smelting & Refining Co.'s refinery at East Chicago, Ind., started.

Oct. 8.—Fire in the Bunker Hill & Sullivan mine in the Cœur d'Alene district, Idaho; one life lost.

Oct. 9.—Utah Copper Co., and other operators in Bingham Cañon resumed operations on a small scale, virtually signalizing the failure of the strike.

Oct. 12.—Fire in the North Mount Lyell mine, Tasmania, imprisoned 90 and caused the death of about 45 men.—Kennecott Mines Co., operating the Bonanza mine in Alaska, declared a dividend of $2,000,000.

Oct. 14.—Hollinger Gold Mines, Ltd., of Porcupine, declared initial dividend of 3 per cent., payable Nov. 2.

Oct. 17.—Two Greek strikers killed by guards at the Steptoe Valley smeltery, whereupon Governor Oddie declared martial law in effect and called out state police to maintain order in the Ely District.

Oct. 19.—New Ophir mill on the Comstock Lode, Nevada, began operations.

Oct. 20.—Cuyuna-Mille Lacs company shipped first ore from the Cuyuna Range in Minnesota.—One hundred twenty men went out on strike at the Cobalt Townsite mine.

Oct. 21.—United Metals Selling Co., entered the domestic lead market as sales agent for International Smelting & Refining Co.

Oct. 23.—Owing to the spread of the fire in the North Mount Lyell mine the management decided to flood it.

Oct. 24.—Nevada Consolidated resumed steam-shovel work at Copper Flat with two shovels.—Hoisting engineer at the White raise of the Bunker Hill & Sullivan mine in Idaho, lost control of skip and 12 men were dropped 200 ft. to the bottom; two men were seriously injured.

Oct. 25.—Representatives of colliery proprietors and miners agreed upon an advance of one shilling per week in wages, affecting about 400,000 men in the colleries of North Wales and England, excepting Northumberland and Durham.

Oct. 29.—Strike at Ely, Nev., declared off by an almost unanimous

vote, the men to return to work at an advance of 25 cents per day as originally offered by the companies.

Nov. 1.—Increase announced in pay of employees at Utah Copper mills, and of engineers, firemen and switchmen on Bingham & Garfield Railroad.

Nov. 5.—Striking miners at Cobalt-Townsite mine return to work under old condutions.—The U. S. Circuit Court of Appeals for the third circuit reversed the decision of the district court and declared that the Butters filter was an infringement of the Moore process patent in the suit of the Moore Filter Co., against the Tonopah-Belmont Development Company.

Nov. 8.—One man killed and five injured by explosion of gas in Simpson-Brooks colliery at Lafayette, Colo.

Nov. 10.—A mine captain and a miner overcome by gas in a winze in the Casey-Cobalt mine in Cobalt district, Ont., fell into 4 ft. of water and drowned.

Nov. 11.—Concentrator of Nevada Consolidated Copper Co., at McGill, Nev., run at full capacity for first time since strike begun in October.

Nov. 12.—Two men killed in strike riots at Waihi gold mine in New Zealand.

Nov. 13—Announcements made that the firm of M. Guggenheim's Sons had joined A. C. Burrage in the exploitation of Chuquicamata copper mines, in Chile.

Nov. 14.—Smeltery of American Zinc, Lead & Smelting Co., at Hillsboro, Ill., put in commission.

Nov. 15.—Miners at Porcupine, Ont., went out on strike in resistance to proposed reduction of wages.

Nov. 18.—Albert Freeman, Josiah Quincy, William J. Morton and Julian Hawthorne brought to trial for alleged use of the mails to defraud in promoting Hawthorne Silver & Iron Mines Co., Ltd., and other companies.

Nov. 19.—First production of sulphur at Bryan Heights, Texas, by Freeport Sulphur Co.

Nov. 24.—Twenty-four men killed by explosion of gas in the St. Martin de Valgalgues mine, near Alais, in the Department of Gard, France.

Nov. 25.—Fifty men caught in a cave-in at Barnum mine, Pittston, Penn.; no fatalities, but about a dozen miners seriously injured.

Dec. 1.—Utah Copper Co. raised wages for surface labor to $2.20 per 10-hour shift, an advance of 20 cents per day, to continue so long as the average monthly price of copper remains above 17 cents.

Dec. 3.—Perseverance stamp mill at Alaska Gold Mines property near Juneau was destroyed by fire.—T. S. Crosley, of New York, bought holdings of La France Copper Co. at auction.

Dec. 9.—Archie L. Wisner, head of the stock brokerage concern of A. L. Wisner & Co., and John J. Myers placed on trial on indictments charging use of the mails in defrauding investors in mining stocks.—A snowslide on Copper Mountain, near Cordova, Alaska, carried away seven buildings on the property of the Great Northern Development Co., and killed nine men.

Dec. 10.—Fire in the West Stewart mine at Butte, a property of the Anaconda Copper Mining Co.

Dec. 12.—Twentieth Century and Jajola combined mine plant at Cobalt destroyed by fire.

Dec. 18.—Strike at Cananea, Mexico, for increase in wage, and a shorter day.—Explosion in Achenbach coal mine, near Dortmund, Germany, killed 31 men.

Dec. 23.—Fire imprisoned 35 men in the Nelson tunnel of the Happy Thought mine at Creede, Colo., escape being effected through a connecting mine.—About 200 Japanese miners were killed by an explosion in the Ubari colliery at Sapporo, on the island of Hokkaido, this being the second serious explosion in this district this year.

Dec. 26.—Strike at Cananea reported broken and mines and smeltery resumed operations.

Dec. 27.—Interstate Commerce Commission ordered an increase in the all-rail freight rate on copper from Lake Superior to New York.

# ALUMINIUM

By J. W. Richards

*Prices.*[1]—Price in London January, 1912, 11.3 cents to 11.73 cents per pound, resulted in larger exportations to the United States. The metal was sold in New York January, 1912, for 18.5 to 19 cents, duty paid.

At these prices the various companies with one exception stated they were losing money. A new convention was formed, resulting in the advance of prices in London to 15.68 to 16.08 cents per pound, while metal for 1913 is quoted at 17.73 cents per pound. The American producers did not join the convention. The advance in price has not checked the demand, which is mainly for automobile and electrical works.

The International Al. syndicate has fixed the price for 1913 deliveries[2] at $380 per metric ton, equal to 17 1/4 cents per pound.

PRICE OF ALUMINIUM AT NEW YORK
(In cents per pound.)

| Grade. | Dec., 1907. | July, 1908. | Dec., 1908. | July, 1909. | Dec., 1909. | July, 1910. | Dec., 1910. | July, 1911. | Dec., 1911. | July, 1912. | Dec., 1912. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 99% pure | 33 | 28 | 24 | 22 | 22 | 22½ | 23 | 20½ | 18½ | 23½ | 26 |
| 90% pure | 32 | 27 | 23 | 21 | 21 | 21 | 21 | ..... | ..... | ..... | ..... |
| No. 12 casting alloy | 32 | 27 | 22 | 20 | 20 | ..... | ..... | ..... | ..... | ..... | ..... |
| No 21 casting alloy | 30½ | 24½ | 22½ | 20½ | 20½ | ..... | ..... | ..... | ..... | ..... | ..... |
| No. 31 casting alloy | 28½ | 22½ | 21½ | 19½ | 19½ | ..... | ..... | ..... | ..... | ..... | ..... |

The above prices were for ton lots or over; the prices for small lots were 2 to 3 cents per lb. higher.

The manufacturers of aluminium, with the single exception of the Italian company at Bussi, adhere to their short-sighted policy of keeping secret as much information as possible concerning the expansion and progress of the industry. They cannot, of course, hide a power house, and when metal is exported the Government publishes the amounts, so those cannot be suppressed; but almost all other important statistical data are inaccessible.

It is a great pity that the statistics of such an important and rapidly-growing industry should be kept from the public; the general public takes a pride in knowing that the industry is expanding, and the producers are losing a large asset when they repel this natural interest of the public in their business, and practically tell the public to let them alone. This is not a proper attitude toward the natural and legitimate interest of the

[1] *Eng. and Min. Journ.* September 21, 1912.
[2] Daily Consular and Trade Reports; *Brass World*, October, 1912.

public in a new industry, and it serves but to alienate the sympathy of the public. Gentlemen, have the foresight to treat your customers with more consideration!

SUMMARY OF ANNUAL CAPACITY.

| | |
|---|---|
| France | 15,750 tons |
| United States | 20,000 tons |
| Scotland | 10,000 tons |
| Switzerland | 8,000 tons |
| Austria | 4,000 tons |
| Canada | 8,000 tons |
| Norway | 2,750 tons |
| Italy | 1,000 tons |
| Total | 69,500 tons |
| Estimated product in 1912 | 50,000 tons |

As to the amounts produced in 1912, few of the works or companies will give any official figures. A reasonable estimate is that the output attained 70 per cent. of the maximum capacity. In 1910, it averaged 70 per cent.; in 1911, we estimated the world output at 75 per cent. of the capacity, or 45,000 metric tons. Foreign consumption did not exceed 55 per cent. of the capacity. In 1912, an estimate of the world's production would be about 50,000 tons.

*United States.*—In 1911, we estimated a production of 28,600,000 lb. in the United States; the United States Geological Survey estimated a consumption of 46,125,000 lb. which, less imports and plus exports, indicates a higher figure for production. The corresponding figure for 1912 is about 49,000,000 lb. No exports of unmanufactured aluminium have been made from the United States.

PRODUCTION, IMPORTS AND CONSUMPTION OF ALUMINIUM IN THE UNITED STATES.

| | Production. | | | Imports. | | | Exports. | Consumption. |
|---|---|---|---|---|---|---|---|---|
| | | | | Crude. | | Mfrs. | | |
| | Pounds. | Value. | Per lb. | Pounds. | Value. | Value. | Value. | Value. |
| 1899.. | $6,500,000 | $2,112,500 | $0.33 | 53,622 | $9,425 | 7,828 | $291,515 | 1,838,238 |
| 1900.. | 7,150,000 | 2,288,000 | 0.32 | 256,559 | 44,455 | 5,989 | 281,821 | 2,056,623 |
| 1901.. | 7,150,000 | 2,238,000 | 0.31 | 564,803 | 104,168 | 5,580 | 183,579 | 2,164,169 |
| 1902.. | 7,300,000 | 2,284,590 | 0.31 | 745,217 | 215,032 | 3,819 | 116,052 | 2,387,389 |
| 1903.. | 7,500,000 | 2,325,000 | 0.31 | 498,655 | 139,298 | 4,273 | 157,187 | 2,311,384 |
| 1904.. | 7,700,000 | 2,233,000 | 0.29 | 515,416 | 128,350 | 478 | 166,876 | 2,494,952 |
| 1905.. | 11,350,000 | 3,632,000 | 0.32 | 530,429 | 106,108 | 33 | 290,777 | 3,015,364 |
| 1906.. | 14,350,000 | 5,166,000 | 0.36 | 770,713 | 154,292 | 1,866 | 364,251 | 4,957,907 |
| 1907.. | 26,000,000 | 10,920,000 | 0.42 | 872,474 | 181,351 | 1,124 | 304,938 | (*b*) |
| 1908.. | 13,000,000 | 4,095,000 | 0.315 | 465,317 | 80,268 | 2,334 | 330,092 | (*b*) |
| 1909.. | 15,000,000 | 3,345,000 | 0.223 | 5,109,843 | 745,963 | 12,878 | 567,375 | (*b*) |
| 1910.. | 12,000,000 | 2,736,000 | 0.228 | 12,271,277 | 1,844,830 | ..... | 949,215 | (*b*) |
| 1911.. | (*e*)28,600,000 | 5,720,000 | 0.20 | (*d*)4,173,308 | 598,272 | (*d*)63,899 | 1,158,603 | (*b*) |
| 1912.. | (*e*)40,000,000 | 9,200,000 | 0.23 | 22,759,937 | 3,092,889 | 428,182 | 1,347,621 | (*b*) |

(*a*) Not reported. (*b*) Impossible to compute accurately in the absence of information as to unold stocks. (*d*) from July 1 only. (*e*) estimated.

It is estimated, however, that approximately 20,000,000 lb. of ingots were produced in the United States the first half of 1912; imports for same

period 10,660,668 lb. make total supply for this period over 30,000,000 lb. Duty is 7 cents on ingots, 11 cents on sheets, tubes, rods and other finished or partly finished forms; estimated that 35 per cent. of production is sold as ingots, 20 per cent. as wire and 45 per cent. in other finished forms.

The *Eng. and Min. Journ.* of June 22, 1912, announced the formation of a new aluminium producing company.

L'Aluminium Francaise, in conjunction with French and Swiss banks and the American Metal Company, Ltd., of New York, has organized the Southern Aluminum Company with a capital of $8,000,000. L'Aluminium Francaise is an amalgamation of the aluminium producers of France, including all the producers in France.

The Southern Aluminium Co. has acquired at Whitney, N. C., water power estimated at 50,000 h.p., which is being developed for the purpose of making aluminium. It is planning to erect a plant with a capacity of 25,000 tons per year. The construction was originally under the direction of Dr. Paul Heroult, who was on the ground executing the preliminary engineering work. The construction will be begun soon, and production of aluminium will begin during the year of 1914. The company has entered into contracts for an ample supply of bauxite. Seven of the largest direct-current generators ever built have been designed for this plant by the General Electric Company. They are each 22 ft. in diameter, 13 ft. high, weigh about 150 tons, and are of 7000 h.p. The plant will contain nine furnace rooms, each 60×150 ft., and an electrode factory. The company has purchased from the old Whitney Company 3,000 acres of land; the dam has been finished and work is being started on the aluminium works, and cement cottages for employees. Plans are under consideration for the second plant of 35,000 h.p. The American Metal Company is reported to also contemplate erecting a plant in the West.

It was announced[1] that the large manufacturers in England, France, Switzerland, Germany and America had agreed upon a new convention to end the competition and low prices which have ruled since the old syndicate was dissolved in 1910. According to the preliminary agreement prices have advanced in London 2.4 cents per pound and in Germany 1/4 cent per pound.

The United States Court at Pittsburgh, on June 7, entered a decree abrogating alleged unlawful contracts of the Aluminum Co. of America, with the General Chemical Co., the Norton Co., the Pennsylvania Salt Mfg. Co., Gustave A. Kruttschnitt and J. C. Coleman of Newark, N. J., and the former company is forbidden to participate in any combination

[1] *Eng. and Min. Journ.*, May 18, 1912.

or agreement to control the output or prices of aluminium. Also it is enjoined from combining, by stock ownership or otherwise, with other manufacturers for this purpose.

Whenever it is shown that substantial competition has arisen in this industry, the decree may be modified by the production of evidence that it is working an injustice. Application for modification cannot be made oftener than once in every 3 years.

It was shown that this company had agreements with the General Chemical Co., the Norton Co., the Pennsylvania Salt Mfg. Co., forbidding their engaging in the manufacture of aluminium or selling bauxite to any one else; with Gustave A. Kruttschnitt and Jas. C. Coleman of Newark, N. J., who agreed not to manufacture or sell aluminium east of Denver for 20 years from Nov. 16, 1910.[1]

*France.*[2]—The year 1912 commenced badly, but in April the principal French and foreign manufacturers arrived at an agreement. The low price of the metal in 1911-12 increased the consumption.

On December 19, 1911, the Société L'Aluminium Francaise was organized by the French manufacturers. This grouping of manufacturers has already started on a large program; being the owner for the whole world, excepting the United States, of the patents and processes of the Societe Generale des Nitrures, with this latter company it has works and plants in France, Norway and United States.

L'Aluminium Francaise now controls the Alumina Works of Mennsis, of the Societe Francaise des Produits Alumineux, the alumina works of Selzaete of the Societe Filiale Belge-Neerlandaise, and the works of Arreau of the Societe L'Aluminium du Sud-Ouest. It has also taken part more or less directly in the establishment of the Societe des forces de l'Eau d'Olle and the Societe des forces Motrices du Montenegro.

The works at Saint-Jean de Maurienne has worked intermittently during the year, producing aluminium nitride, while the works at Vizille in France and of Arendal are being constructed. Experiments are being made to reduce the temperature of 1800° necessary for the reaction in the Serpek furnace.

The French manufacturers have made colossal efforts in 1912, and yet the execution of the vast program has only commenced. They will construct new works, harness new hydraulic forces like those of Veneon, and Chateau-Arnoux. Millions of francs will be necessary for its expansion. An idea of the size of these plants may be had when we remember that in an aluminium works the investment is about 5,000,000 francs per thousand tons of aluminium manufactured yearly. At the

[1] *Eng. and Min. Journ.*, June 15, 1912.
[2] *Journal du Four Electrique*, January 1, 1913.

beginning of 1912, L'Aluminium Francaise had an annual capacity of 12,000 to 13,000 tons of metal, and at the present time 2000 to 3000 tons more.

These considerations show that 1913 will be a year of extreme activity for the aluminium industry in all countries, for it is necessary to be able to provide metal to supply the new and large demands.

The power required is 30 to 35 kw.-hours per kilogram of Al. Yearly production 200 kg. per horsepower. Cost in France 1.5 to 2 francs per kilogram, of which a heavy item is interest on the capital involved, which is usually over 3000 francs per yearly production of 1 ton.

The French works are : Froges, capital 15,000,000 francs; works in La Praz, 15,000 h.p.; works in La Sassaz, 15,000 h.p.; works in La Shertan, 20,000 h.p.; Pechiney and Co., capital 7,500,000 francs; works at Calypso, 20,000 h.p., works in St. Filix, 4000 h. p.; works in St. Jean de Maurienne, 12,000 h.p.

*Switzerland.*—The firm Gebrüder Giulini G. m. b. H., home office Ludwigshafen on the Rhine, Germany, operates an aluminium works at Martigny, Canton Vaud, Switzerland, and an aluminium rolling mill and casting plant at Wutöschingen, Baden, Germany. They refuse to state their production officially, since they are not a member of the Aluminium Syndicate and, therefore, are interested in not divulging figures on this subject.

Through outside sources, however, we estimate their production at 600 tons per year.

*Canada.*—Exports of aluminium in 1912 in bars 182,857 cwt. equal to 18,285,700 lb., value $2,002,363, equals $0.11 per pound.

*India*—The imports into Madras, in four classes of manufactures of aluminium ware, are increasing. For the year ending March 31, 1912, the imports were valued at $240,040 of which $50,000 are in sheet.

*Norway.*—Thos. H. Norton,[1] states that the works at Vigeland near Christiansand exported 486 tons in 1909, 1019 tons in 1910. The 1910 production was sold for $437,000 equal to 43 cents per kilogram or 19.5 cents per pound. A considerable amount is used in Norway in the nitric acid plants for conduits and pipes.

The Aktieselskabet Vigelands Brug at Vennesla near Christiansand has sold out to the British Al. Co. Its power, when entirely exploited, will amount to 14,000 h.p. The production from imported raw material is estimated at 2000 tons in 1912, and at 1800 in 1911. Exports from two factories, Vigeland and Stangfjord, were 1792 tons in 1911 and about the same in 1912, although one of these did not produce all the time during 1912.[2]

[1] *Journ. Ind. and Eng. Chem.*, Sept., 1912.
[2] *Echo des Mines*, April 7, 1913.

*Germany.*—The imports of aluminium into Germany in 1912, the exports therefrom and their value are as follows: Imports 18,112 metric tons, value 22,278,000 marks, average value 1.23 marks per kilogram equal $0.14 per lb. Exports 2045 tons, value 2,857,000 marks as manufactured articles.

*Italy.*—The Societa Italiana per la Fabricazione dell' Alluminio, situated at Bussi, Province of Aguila, possesses bauxite mines in the Abruzzi, and purifies it by the system Baeyer, producing about 2,000 tons of purified alumina per year, part of which is converted into aluminium sulphate.

The production of aluminium during 1912 was 820 metric tons of 99 to 99.5 per cent. metal, almost all of which was absorbed by the Italian market. The necessary electrodes are manufactured in the Bussi works, the annual production being 700 to 800 tons. (Private communication from A. Dapples, Director.)

## Ores of Aluminium

*Bauxite.*[1]—W. C. Phalen in "Mineral Resources of the United States" describes the prospecting for and mining of bauxite as carried out in Arkansas, Georgia, Alabama, and Tennessee, speaks of the deposit in Botetourt County, Virginia. In Arkansas the deposits vary up to thirty feet in thickness, resting directly on kaolinized syenite, and occur in at least three forms: granitic, pisolitic and compact. As to origin it is related to the syenite.

The Tennessee deposits are on the southeast slope of Missionary ridge near Chattanooga and are on the same nature as Georgia deposits.

The bauxites in Wilkinson County, Georgia, are no way connected with those in the northwest part of the State either geographically or geologically. They are on the margin of the coastal plain. They occur in beds resting directly upon cretaceous clays or as nodules in the clays. Up to 10 ft. in thickness the ore is either pisolitic or concretionary, white or cream color to bright red. The bauxite has been found near the clay at its contact with the overlying red sands; similar geological conditions prevail in Twiggs, Washington, Glascock, McDuffey and Richmond counties. Bauxite may be found in any or all of these.

The total production in France is 18,000 tons yearly, the average value being 12 to 14 francs per ton at the mines. Dealers: Union des Bauxites Montpellier; Societe des Bauxites de France, Marseilles. Average alumina 60 per cent., iron-oxide 25, silica 3, water 12.

[1] *Min. and Sci. Press*, September 7, 1912.

## ALUNITE[1]

$K_2O.3Al_2O_3.4SO_3.6H_2O$, according to experiments performed in the laboratory of the Geological Survey, gives off on ignition all of its water and three-fourths of its sulphuric acid. On leaching the residue in water, potassium sulphate is dissolved leaving insoluble $Al_2O_3$ behind. The average amount of potassium leached out is 17.9 per cent. of the original material, representing 92 per cent. of the total potash present. W. T. Schaller states that 32.7 per cent. of the alunite consists of available potassium sulphate, extractable by leaching with water, the remaining 67.3 per cent. being nearly pure $Al_2O_3$. The material used came from Marysvale, Utah, but alunite occurs in the Rosita Hills, the Rica Mountains, at Silverton and Cripple Creek, Colorado; also in Tres Cerritos, California; Clifton and Morenci, Arizona; and Beaver Co., Utah.

## ALUMINA[2]

In a paper by A. H. Cowles and A. Kayser, Chemist of the Electrical Smelting and Al. Co., the process is described for using clay, carbonaceous material and salt, made into perforated briquettes, dried and passed on flat cars through a long tunnel-furnace, bringing them to 1035° C. Steam is blown into the discharge end. Temperature is controlled by oil heating and measured by pyrometers. Reaction varies according to composition of mixture but is typically $Al_2Si_2O_5+4\,NaCl+2H_2O+H_2O+C+O=Na_4Al_2Si_2O_9+4HCl+CO$. The HCl is condensed and is free from arsenic and has only traces of sulphuric acid. Briquettes contain 30 to 35 per cent. $Na_2O$. The iron passes off as chloride.

The briquettes are ground with sufficient lime to form silicate according to the formula $Na_4Al_2\,Si_2O_9+4CaO=2Ca_2\,SiO_4+Na_4\,Al_2O_5$.

The mixture is heated in the rotary cement furnace to clinkering, and then broken into fragments for leaching. The residue of lime silicate heated in a cement furnace with one-half additional lime gives hydraulic cement. The solution contains sodic aluminate, and is treated for soda and alumina.

If potash feldspar is used as raw material the potassium is obtained. Reactions have been worked out at the plant at Sewaren, N. J. The hottest part of the large furnace is at 1450° F. (788° C.). Iron chloride is produced proportional to the amount of iron in the clay.

[1] See also article on Bauxite, this volume of MINERAL INDUSTRY.
[2] *Eng. and Min. Journ.*, September 21, 1912.
Proceedings *Eighth Int. Cong. of Appl. Chemistry.*
MINERAL INDUSTRY, Vol. XXI, under Bauxite.

## Working and Uses

*Effect of Beer.*[1]—The *German Brewing Journal* says that for 4 years tuns of sheet Al, used in a fermentation cellar to contain beer, showed no sign of injury by chemical action. The slight scale formed on the aluminium consisted, mainly, of calcium phosphate, which was removed by nitric acid, leaving the metal unaffected. Contact of Al with copper and brass under these conditions will corrode it, and it also corrodes with moisture and air. For this reason it is recommended to coat the outside of the tuns with lacquer to protect them from rusting. The inside needs no such protection. Hard-rolled aluminium oxidizes easier than soft metal.

*Extruded Shapes.*—The difficulties[2] encountered in making extruded shapes have been largely surmounted, and these shapes and tubing are now turned out with high tensile strength. The production of such shapes is increasing. An extension of the tubing plant of the Al. Co. of America at South Kensington, Pa., is reported.

*Foil and Powder.*[3]—An account is given of the processes conducted at La Praz and Charleville-sur-Andelle by the Societe francaise de Couleurs métalliques. In the manufacture of aluminium foil the metal delivered to the works in the form of ingots, 700×320×120 mm. (cast at 750°–775° C.) is first hot-rolled at 420° C. to a thickness of 3.5 mm. and then cut into strips 8 cm. wide, which, after being annealed at 420° C., are cold-rolled to 0.04 mm. in six stages, further reduction in thickness being then effected by continued rolling or by hammering. In the former case the metal bands are first greased, then rolled in pairs to 0.02 mm. and subsequently in fours to the desired thickness of 0.01 mm., the foil thus being obtained in lengths of about 16 meters. In the latter case the bands are made into packets of 500 each and beaten by pneumatic hammers, each packet being placed between two thin sheets of zinc; when the thickness of the metal reaches 0.03 mm. the packets are hammered in pairs to 0.02 mm. and then in fours to 0.01 mm. The wastage in either case is very considerable, only about 33-35 per cent. of the 0.04 mm. metal employed being obtained as good foil, 1 square meter of which weighs about 27 grm.; the waste foil is used for the production of aluminium powder. Before being finally trimmed and cut to size, the sheets of foil are either mechanically separated, or embossed by means of suitable rolls, since in the absence of the layers of air thus introduced between the sheets the metal is liable to become autogenously soldered at the cut edges. In the manufacture of aluminium powder it has been found necessary to employ the foil as the

[1] *Brass World*, November, 1912.
[2] W. C. Phalen, Advance chapter, Mineral Resources, 1912, *U. S. Geol. Surv.*, 1913; Mineral Resources, 1910, *U. S. Geol. Surv.*
[3] L. Guillet, *Rev. Met.*, IX, 147–159, 1912.

raw material, the powder yielded by other forms of the metal being of too granular a character for use in the preparation of paint. The comminution of the foil is conducted in a series of stamp mills in each of which the closed mortar-box is provided with a circle of 12 stamps actuated from a central shaft to the lower end of which a scraper or plough is attached. Caking of the metal is prevented by the scraper, which also causes the charge to be periodically thrown against a screen inserted in the side of the mortar; the screen is provided with an exterior sliding box for collecting the metal passing through. After further classification, the finer portion of this product is mixed with about 2 per cent. of stearine (to prevent agglomeration and autogenous soldering of the particles during the fine grinding) and passed to a second series of stamp mills, the product of which is screened through silk bolting cloth (No. 200). The powder passing through the latter is then classified by a kind of winnowing process in "elevators," each comprising a vertical brass cylinder, 2 meters high and 0.80 meters in diameter, in which a central vertical spindle—to which horizontal wings or paddles are attached—is adapted to rotate, and provided with receptacles arranged at different levels upon a helical rail attached to the interior wall. The powder is fed through a tube into the lower part of the cylinder, the rotation of the spindle being so adjusted that the lighter particles or flakes become suspended in the air and are deposited in the peripheral receptacles at levels corresponding to their weight and physical condition; the coarser particles remaining at the bottom of the cylinder are returned to the fine-grinding mills. The product from the "elevators" is finally treated for ten hours in polishing machines consisting of horizontal, rotary cylinders of striated sheet steel, 1.20 meters long and 0.60 meters in diameter. The polishing of the metallic powder is effected by means of brushes attached to the axis and bearing upon the interior wall of the cylinder through the whole of its length. Since conditions favorable to ignition or explosion are liable to be developed within the fine-grinding mills, elevators and polishing machines, the various units are of relatively small capacity and are so disposed, both in relation to each other and to the other portion of the works, as to localize any damage that may arise from this cause.

Owing to the present high price of tin, Al foil is cheaper for wrapping cheese and other articles of food.

*Castings.*—Shrink holes[1] in cast Al are to be filled by a mixture of aluminium 1, zinc 11, tin 29, phosphor tin 1. This is cast in sticks and is more fusible than Al. As soon as the castings are taken out of the molds, while still hot, the holes are rubbed inside with a stick of the solder until the hole is filled up. The same alloy can be used as a solder for soldering Al.

[1] *Foundry*, October, 1912.

*Machining.*—Hayden A. Kern[1] of Dayton, Ohio, uses the following lubricant for machining Al, such as turning, threading, tapping, etc.

| | |
|---|---|
| Bees' wax | 1 lb. |
| Gasoline | 5 lb. |
| Turpentine | 1 lb. |

The bees' wax is melted, the flame removed, turpentine then added and stirred, and when still liquid the gasoline added, the mass made to a paste and applied like oil.

*Coloring.*—S. Axelrod[2] (U. S. P. 1,023,291, April 16, 1912, assigned to the General Electric Company of Schenectady, N. Y.) treats the surface with solution of cobalt salt and then heats, the color grades from steel-gray to brown and finally black depending on the temperature. Heating is done by a muffle or blow-pipe, temperature used is low. The low temperatures produce steel gray, higher a brown and still higher a dead black. The dead black is stated to be durable, and not to be rubbed off by friction.

*Welding.*—(Franz-Jordon Patents.) The processes of heating Al almost to welding heat, and the metal to which it is to be welded only so far that it will not oxidize in the air. At these temperatures they are rolled or hammered or otherwise welded together. Al may be welded to alloys in the same manner if their melting point is higher than that of Al.

*Solder.*—The sales of Richards' solder from 1892 to 1912, by the Aluminium Industry A. G. Neuhausen, averaged 195 kilos per year, a total of 3914 kg. in 21 years. The sales in 1912 were 729 kilos, equal to 1600 lb. The sales in the United States are greater than the above figures.

Richard Seifert of Union Hill, New Jersey, patents a solder containing tin 38, phosphor tin 32, zinc 30. The solder is used with 20 per cent. of its weight of rosin as a flux, with a soldering iron or a blow pipe.

Carl E. Steinweg of Luendenscheid, Germany, recommends as a flux cryolite 30, salt 35, potassium chloride 35. The solder is made in a tube and the flux placed inside it constituting a solder stick. When heated the flux drops first and then the solder, effectually soldering the joint. The flux itself is not claimed in the patent specification.

Charles R. Erkens, Simplex Al. Solder Co. Inc., New York City, composes the following: Tin 60, zinc 15, lead 10, antimony 5, chromium 5. The metals are melted and then treated with 35 grm. of salicylic acid and 10 grm. of calcium to each 5 lb. of alloy, and also 2 grm. of sul-

[1] *Brass World*, November, 1912.
[2] *Brass World*, Vol. VIII, No. 5, May, 1912.

phur. The sulphur acts as "binding agent." The solder is used with the ordinary solder fluxes for soft solder and in the same manner.

## Alloys

*Duralumin*, the aluminium-magnesium alloy of Wilm, is said to obtain its excellent properties by the following heat treatment.[1] The alloy is heated to 500° C. quenched in water and then allowed to stand. The alloy is at first soft, but becomes harder and stronger after standing. If slowly cooled from 500° the alloy is at first harder but on standing loses its hardness. The metal should not be worked directly after hardening. Heating to 200° causes loss of hardness.

The Institute of Mechanical Engineers, Committee on Alloys, has reported its investigation of aluminium-zinc alloy. The composition giving best results was:

| | |
|---|---|
| Aluminium | 72 per cent. |
| Zinc | 25 per cent. |
| Copper | 3 per cent. |

In sand castings and chill castings the tensile strength is 36,500 and 40,500 lb. per square inch respectively. It can be hot-rolled, into perfectly sound bars; if rolled too hot it breaks into powder and if too cold becomes very hard. It cannot be drawn into wire, the section obtained was 3/8 in. diameter. The 1/2 in. diameter rolled bar gave tensile strength of 63,400 per square inch, an ultimate limit 54,000 per square inch and elongation 21 per cent. Drawn cold to 3/8 in. diameter, the tensile strength was 66,600 lb., elastic limit 63,000 lb., elongation 13 per cent., specific gravity 3.29. Under compression 58,000 lb. ultimate strength, 48,400 lb. elastic limit. The general conclusion is that this alloy has the greatest strength in proportion to its weight of any yet discovered.

*Alloys with Cerium.* R. Vogel.[2]—An equilibrium diagram of the system is given. The metals alloy to the compounds $Ce_3Al$, $Ce_2Al$, CeAl, $CeAl_2$ and $CeAl_4$. $CeAl_2$ is not affected by strong hydrochloric, nitric and sulphuric acid, and the alloys generally are less readily attacked by acids than the constituent metals. They may be burnt in the Bunsen flame, but only those rich in cerium are pyrophoric. $CeAl_2$ is the hardest, and is very brittle, with a melting-point of 1455° C.

*Augalite.*—Prof. G. Jacquier[3] has invented a hard light alloy suitable for pipes, tubes and plate to resist corrosion, containing aluminium 90 parts, bismuth 2, copper 6, silicon 2.

*Alloys with Platinum.*—Chouriguine, in *Comptes rendus*,[4] states that platinum wire was added to molten Al in an electric furnace. Lithium

[1] A. Wilm, *Metallurgie*, VIII, 225.
[2] *Zeit, Anorg. Chemie*, LXXV, 41.
[3] *Foundry*, October, 1912.
[4] *Brass World*, September, 1912.

chloride was used as flux, the pieces of Al being soaked in a solution of lithium chloride and dried before melting. With less than 10 per cent. Pt alloys were white and soft and very malleable. Between 10 and 70 per cent. the alloys are hard and very brittle but still white. Over 70 per cent. the alloys are yellow and brittle. At 90 per cent. Pt the alloy becomes white again but still brittle. No commercial use is suggested; they are too brittle to be used in jewelry.

*Alloys with Bismuth.*[4]—G. Jacquier of Belgravia, Transvaal, patents (U. S. Patent 1,019,963, 1912) an anti-corrosive alloy, said to be suitable for tanks, pipes, ropes, valves, pumps, etc. Its composition is given as:

| | | | |
|---|---|---|---|
| Aluminum | 92 per cent. | Aluminum | 91 per cent. |
| Bismuth | 2 per cent. | Bismuth | 2 per cent. |
| Copper | 5 per cent. | Copper | 5 per cent. |
| Silicon | 1 per cent. | Magnesium | 2 per cent. |

[4] *Journ. Ind. and Eng. Chem.*, June, 1912.

# ALUNDUM

Alundum is oxide of alumina ($Al_2O_3$) in crystalline form, as produced in the electric furnace. The sole producer is the Norton Company, Worcester, Mass., whose electric furnace plant is located at Niagara Falls, N. Y. Alundum is a reproduction of one of the minerals of nature, corundum, in uniform and unlimited quantity and of a quality superior to the natural product for commercial uses.

It is made by fusing the mineral bauxite in the intense heat of the electric arc as described below. Chemically, bauxite is the purest form of aluminum oxide available in nature, and was considered infusible until the invention of the alundum electric furnace process.

In chemical composition, alundum is similar to the ruby and sapphire, the hardest natural minerals except the diamond. Alundum is not radically different in chemical composition from the mineral corundum, but usually contains less of such impurities as iron and silica. The manufacture of alundum is under such control that it is possible to produce this abrasive material in different combinations of hardness, sharpness and toughness, which makes it applicable to a wide range of uses. That it possesses superior abrasive qualities is made evident by the constantly increasing demand for abrasive products made of alundum since its introduction into the abrasive field.

PRODUCTION OF ALUNDUM IN THE UNITED STATES.

| Year. | Pounds. | Value. |
|---|---|---|
| 1905 | 3,612,000 | 252,840 |
| 1906 | 4,331,233 | 303,186 |
| 1907 | 6,751,444 | 405,086 |
| 1908 | 3,160,000 | 189,600 |
| 1909 | 13,578,000 | 814,680 |
| 1910 | 13,410,000 | 804,600 |
| 1911 | 11,116,000 | 666,960 |
| 1912 | 13,266,486 | 795,989 |

The bauxite used by the Norton Company is selected in the southern states of the United States and only the highest quality is used for this purpose. Before it is ready to go into the electric furnace it passes through the processes of washing, drying and calcining to remove water chemically combined in it. The furnace is of a special type consisting essentially

of a crucible 4 ft. in diameter by 5 ft. high, having two carbon electrodes 4×12 in. in cross-section inserted therein. Each furnace consumes several hundred horse-power. The bauxite mixture is put directly into the arc in regular quantity, fuses and gradually fills the pot. Each ingot formed in the furnace weighs about 2½ tons. It passes through many operations of crushing and grading before it is reduced to size and ready for commercial use.

Alundum was first used only in the manufacture of grinding wheels. Norton Company later used it in the manufacture of sharpening stones and there is now an extensive use for it in the grain form for polishing metal and mineral products and for refractory products as described below. Abrasive wheels made of this material are being increasingly used in the cut glass and lens industries.

As alundum possesses many properties which make it valuable for use in the manufacture of refractories and laboratory ware, a line of refractory articles for general laboratory use, electric furnace parts, etc., was produced in the year 1910, and has met with marked success. Alundum has valuable properties for resistance to heat and corrosive actions of acids, oxides, molten metals, etc.; the melting-point of alundum is 2050° C. and that of the bonded refractory article slightly below this. Crucibles made of bonded alundum have been used repeatedly, without injury, for melting pure platinum; the thermal conductivity is 2.1 times that of ordinary fire-brick and 1.6 times that of chemical porcelain; its specific heat is higher than that of most refractory articles, recent determinations showing it to be between 0.195 and 0.198 at 20° and 100° C.; electrical resistance of bonded refractory articles is greater than that of porcelain even at high temperature; its inactivity as compared with materials ordinarily used makes it especially adapted as a protection against corrosion of wire heating elements in electric furnace work and it has also been found of advantage in the case of filtering appliances; having the comparatively low coefficient of expansion of 0.0000071, it is not affected greatly by changes in temperature.

Alundum is used for combustion boats, ignition and filter crucibles, extraction thimbles, filter dishes, muffles, tubes, and cores for all of which uses it has been found to be successful. For melting crucibles, while somewhat porous for slag, it is especially serviceable for melting metals of high fusion point. Two distinct varieties of alundum are produced, one nearly pure white, the other, owing to slight impurities, being reddish-brown. The purer variety has a specific gravity of four, conducts heat somewhat better than fire-clay and resists the action of all aqueous and alkaline solutions. Experiments have also been made with alundum brick for furnace linings, but lime and magnesia vapors when present are

apt to cause flaking off and therefore make the increase in life over other brick too little to warrant the extra cost. The use of alundum brick in roofs where high temperatures are necessary has shown that it will stand in cases when silica brick would be rendered useless in five or six hours.

[1] L. E. Saunders, *Trans. Am. Electrochem. Soc.*, XXI, p. 333.

# AMMONIA AND AMMONIUM SULPHATE

By W. N. McIlravy

During the year 1912 there was a considerable increase in the volume of by-product coke production, and a corresponding advance in the quantity of ammonia recovered. Reckoning all forms as sulphate of ammonia, the production in the United States was 165,000 net tons, as against 127,000 tons in 1911, an increase of 38,000 tons. Of this total about 130,000 tons is attributable to the by-product coke ovens and 35,000 tons to the coal, gas, and bone carbonizing works, the gas works being responsible for most of the output and all of the increase. The high price of oil available for use in the carburetted water gas process and better carbonizing methods, have tended to force the coal gas process to the front.

The addition to the active by-product coke ovens comprise the 300 ovens of the Bethlehem Steel Co., the 280 ovens at Corey, Ala., and the 35 ovens of the Coal Products Mfg. Co., at Joliet, Ill. Some of the increase, however, must be credited to the plant at Gary, Indiana, part of which did not come into operation till the latter part of 1910, and to the more continuous operation of some of the other plants.

The new plants that are expected to come into operation in 1913, are the 54 Semet-Solvay ovens at Ashland, Ky., the 68-oven plant of the Republic Iron and Steel Co., at Youngstown, Ohio, the 41-oven plant of the Indianapolis Gas Co., at Indianapolis, the 56 ovens of the Northwestern Iron Co., at Mayville, Wis., and the plant of the Inland Steel Co., at Indian Harbor, Ill. Besides these plants the following additions to existing plants are expected to come into production before the close of the year: Delray, Mich., 40 ovens; Cleveland, Ohio, 51 ovens; South Chicago, Ill., 80 ovens; Tuscaloosa, Ala., 20 ovens; Woodward, Ala., 30 ovens; Citizens Gas Co., Indianapolis, Ind., 50 ovens. According to these figures the ovens added in 1912 numbered 615, and those scheduled for 1913 upward of 470.

Table I gives the production of ammonia recovered in the United States from the carbonization of coal, bone, etc., during each year, reckoned as sulphate, for the past 14 years, together with the proportion due to the by-product coke ovens alone. The figures include the production at Sault Ste Marie, Ontario. The increase in 1912 over the preceding year is the largest annual addition yet made in the history

of the industry, and has increased the proportion of coke oven ammonia to the total from 75 per cent. to 79 per cent. Such an increase in production is on a par with some of the increases that have occurred almost annually in the German output, although as will be noted later, Germany has by no means limited its gains to this scale.

TABLE I.—UNITED STATES AMMONIA PRODUCTION, EXPRESSED IN SULPHATE EQUIVALENT.
(Tons of 2000 lb.)

| | 1899. | 1900. | 1901. | 1902. | 1903. | 1904. | 1905. |
|---|---|---|---|---|---|---|---|
| By-product coke ovens | 6,000 | 13,800 | 15,279 | 18,483 | 24,098 | 32,653 | 41,864 |
| Coal gas and bone carbonising works | (a)13,500 | (a)13,800 | (a)14,000 | (a)17,641 | 17,775 | 22,011 | 23,432 |
| Total | 19,500 | 27,600 | 29,279 | 36,124 | 41,873 | 54,664 | 65,296 |
| Percentage from coke ovens | 31 | 50 | 52 | 51 | 57 | 60 | 64 |

| | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|
| By-product coke ovens | ..... | 62,700 | 50,073 | 75,000 | 86,000 | 95,000 | 130,000 |
| Coal gas and bone carbonising works | ..... | 36,609 | 33,327 | (a)31,500 | (a)30,000 | (a)32,000 | (a)35,000 |
| Total | (a)75,000 | 99,309 | 83,400 | 106,500 | 116,000 | 127,000 | 165,000 |
| Percentage from coke ovens | ..... | 62 | 60 | 70 | 74 | 75 | 79 |

(a) Estimated.

The consumption of the United States, in sulphate and equivalent, footed up to 232,000 net tons as against 230,743 tons for the year before. This is not, as might at first appear, considering production figures, a sign that the capacity of the home market has been reached, but is the result of a record cotton-seed meal crop and unfavorable agricultural conditions in the spring of 1912, bringing about a contraction in the demand for fertilizers which was felt in the market for other materials as well as sulphate of ammonia. For example, the nitrate of soda takings for the East coast were 46,640 tons less than in 1911.

The imports of sulphate of ammonia were 67,003 tons, as against 103,743 tons in 1911, a considerable drop, but it must be remembered, not quite as much as the actual increase in home production. The United States ranks third in ammonia production, but is second only to Germany in point of consumption.

*Market.*—The price figures given in Table II are the result of averaging the weekly open market quotations at New York for the year. The average for 1912 is $65.95 per net ton, the highest since 1894. This corresponds to 16 cents per pound of actual nitrogen. For 1911 the average price was $62.21 per ton and for the ten years preceding 1912 the average price was $60.46 per ton. The price movement for the year

1912 was not wide in range, the weekly quotations rising from $3.20 per 100 lb. in January to $3.40 in May and June, then receding to $3.25 and varying within 5 cents either way from this to the close of the year. The average price or the first half was $3.35 and for the second half, $3.24.

*England.*—The figures in Table III show that England has not increased her output this year, but is estimated to have made 379,000 gross tons as against 384,976 gross tons in 1911. This decrease is due to the effect of labor troubles in the early part of 1912, and not to any permanent contraction of the producing industries. In fact, additions to the coke ovens operating with by-product recovery are projected, that promise a return to the normal rate of increase.

TABLE II.—UNITED STATES AMMONIA CONSUMPTION, EXPRESSED IN SULPHATE EQUIVALENT.(a)
(In tons of 2000 lb.)

| Year. | 1903. | 1904. | 1905. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|---|---|---|
| Imports..... | 16,777 | 16,667 | 15,288 | 9,182 | 32,669 | 34,274 | 40,192 | 63,178 | 103,743 | 67,003 |
| Total Consumption... | 58,650 | 71,331 | 80,584 | 84,182 | 132,000 | 121,874 | 149,192 | 179,178 | 230,743 | 232,003 |
| Average price | $62.10 | $61.71 | $62.92 | $62.33 | $61.93 | $59.90 | $56.04 | $55.60 | $62.21 | $65.95 |

(a) The figures for consumption and price are for the calendar year, while those for imports are for the fiscal year ending June 30th.

TABLE III.—AMMONIUM SULPHATE AND SULPHATE EQUIVALENT PRODUCED IN THE UNITED KINGDOM.
(Tons of 2240 lb.)

| Year. | 1905. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|---|
| Gas works..... | 155,957 | 157,160 | 165,474 | 165,218 | 164,276 | 167,820 | 168,783 | 166,000 |
| Iron works..... | 20,376 | 21,284 | 21,024 | 18,131 | 20,228 | 20,139 | 20 121 | 20,000 |
| Shale works..... | 46,344 | 48,534 | 51,338 | 53,628 | 57,048 | 59,113 | 60,765 | 61,000 |
| Coke ovens..... | 30,732 | 43,677 | 53,572 | 64,227 | 82,886 | 92,665 | 105,343 | 132,000 |
| Producer gas and carbonizing works..... | 15,705 | 18,736 | 21,873 | 24,024 | 24,705 | 27,850 | 29,964 | |
| Total..... | 269,114 | 289,391 | 313,281 | 325,228 | 349,143 | 367,587 | 384,976 | 379,000 |

These figures are from the Alkali Inspector's reports, except for 1911, which are estimates given out by Messrs. Bradbury & Hirsch.

England now occupies the second place as a producer of sulphate of ammonia, her largest annual output being behind that of Germany by over 100,000 tons.

The consumption in England for all purposes is given as about 90,000 gross tons for 1912.

The average price of sulphate of ammonia at Liverpool for the year was £14 7s. 9d. per gross ton, a gain of 12s. 9d. over the average for the year before, and equivalent to $62.55 per net ton. This is the highest yearly average in England since 1884, and outside of 1912 is the highest monthly average since that date.

Although no longer the largest producer, England is still by far the largest exporter of sulphate of ammonia. Her export quota for 1912 was 286,864 gross tons, as against 291,883 gross tons the year before, the decrease being due to the diminished production already referred to. Of this amount, Japan still receives the largest share, taking 86,659 tons, Table VI, Spain and Portugal second, with 61,460 tons, the United States third with 39,333 tons, Java fourth with 33,554 tons, and Italy fifth with 13,542 tons. The remaining 52,000 tons were distributed among France, Germany, Belgium, Holland, The Canaries, British Guiana, West Indies, Mauritius and elsewhere in quantities less than 10,000 tons.

The fact that Japan, taking 75,000 tons last year, has increased her demands by over 11,000 tons, is worthy of note, and indicates that sulphate of ammonia has gained an esteem in the agriculture of that country, beyond what had been at first expected. The small amount taken by the United States, as noted above, may be ascribed, in part, to increased home production and in part to temporarily unfavorable agricultural conditions.

*Germany.*—The production of ammonia in Germany has made one of the surprising increases that have so often occurred in the producing industries of that country, and according to the statement given out by the *Deutsche Ammoniak-Verkaufs-Vereingung*, amounts to 492,000 metric tons as against 418,000 tons in 1911, an addition of 74,000 tons. Such an advance in the face of the development of the producing in-

TABLE IV.—PRODUCTION OF AMMONIUM SULPHATE AND SULPHATE EQUIVALENT FROM BY-PRODUCT COKE OVENS AND GAS WORKS IN GERMANY.
(In metric tons of 2204.6 lb.)

| Year. | 1904. | 1905. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|---|---|
| Coke ovens | 152,000 | 168,000 | ..... | 257,000 | ..... | 270,000 | 313,000 | 358,000 | ..... |
| Gas works | 21,000 | 22,000 | ..... | 30,000 | ..... | 60,000 | (e)60,000 | (e)60,000 | ..... |
| Total | 173,000 | 190,000 | 235,000 | 287,000 | 313,000 | 330,000 | 373,000 | 418,000 | 492,000 |

For 1903–4–5, see *Zeit. f. angew. Chem.*, Sept. 14, 1906.
*Deutsche Ammoniak-Verkaufs-Vereinigung*, 1906–07–08–09–10–11.
(e) Estimated.

dustries previously attained is astounding, and would be hard to believe were the authority less reliable. Table IV gives the figures of production for the last ten years. The German exports and imports were as follows:

| Sulphate of Ammonia. | 1912. | 1911. | 1910. |
|---|---|---|---|
| Imported (metric tons) | 23,098 | 24,463 | 31,400 |
| Exported | 67,148 | 74,410 | 92,996 |
| Net exports | 44,050 | 49,947 | 61,596 |

These figures show that the net exports were a little less in 1912 than in 1911, although they were less in 1911 than in 1910, an annual decrease in exports in both instances, although the increase in production has been so surprising. As may be naturally inferred, this involves an increase in home consumption, the estimated figures for the past six years being as follows:

| | Tons. |
|---|---|
| 1907 | 240,000 |
| 1908 | 260,000 |
| 1909 | 274,000 |
| 1910 | 350,000 |
| 1911 | 360,000 |
| 1912 | 425,000 |

The development that these figures show in German agriculture speaks well for the methods of farming that prevail, as well as for the qualities of sulphate of ammonia as a fertilizer.

*France.*—The recovery of ammonia in France is given in Table V for the last five years, revised according to the data furnished by *L'Engrais*, the representative journal of the fertilizer industry in France.

TABLE V.—AMMONIUM SULPHATE AND SULPHATE EQUIVALENT PRODUCED IN FRANCE.
(Tons of 2204.6 lb.)

| | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|
| Gas works, Paris and vicinity | 14,000 | 17,500 | 19,600 | 20,600 |
| Provincial gas works | 4,000 | | | |
| By-product coke ovens | 22,800 | 26,000 | 29,000 | 33,000 |
| Sewage disposal | 11,300 | 12,200 | 12,000 | 12,000 |
| Shale works | 900 | 1,600 | 1,900 | 2,900 |
| Various sources | 500 | | | |
| Total | 53,600 | 57,300 | 62,500 | 68,500 |

These figures show that the amount recovered in 1912 was 68,500 metric tons, compared with 62,500 tons in 1911, a gain of 6000 tons. As is usually the case, the increase is attributed mostly to by-product coke ovens, 4000 tons coming from that source, and 1000 from the gas works.

The consumption may be approximated from the ensuing figures for exports and imports.

| | |
|---|---|
| Imports (1912) | 25,000 metric tons. |
| Productions | 68,500 metric tons. |
| | 93,500 metric tons. |
| Exports | 2,000 metric tons. |
| Available for consumption | 91,500 metric tons. |

This amount may be compared with the corresponding figure for 1911, which was 81,500.

*Japan.*—As has already been noted, Japan has taken more sulphate of ammonia from England in 1912 than ever before. She has also drawn supplies from Germany and elsewhere, as shown by the following figures

for imports and production furnished by the *Imperial Commercial Museum* of Tokyo, Japan.

| Year. | Imports. | Production. |
|---|---|---|
| 1907 | 69,611 metric tons | ..... |
| 1908 | 73,751 metric tons | ..... |
| 1909 | 51,336 metric tons | 1,232 metric tons |
| 1910 | 77,070 metric tons | 1,643 metric tons |
| 1911 | 82,491 metric tons | ..... |
| 1912 | 93,999 metric tons | ..... |

*World's Production.*—In Table VII is given an estimate of the world's ammonia production, reckoned as sulphate, the output of each country having been reduced to metric tons for convenience in tabulating. The total, it will be noted, now amounts to 1,320,900 metric tons.

TABLE VI.—EXPORTS OF SULPHATE OF AMMONIA FROM THE UNITED KINGDOM TO JAPAN.
(Tons of 2240 lb.)

| 1902. | 1903. | 1904. | 1905. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|---|---|---|
| 2,429 | 3,612 | 14,981 | 33,861 | 33,237 | 64,270 | 38,745 | 49,275 | 57,360 | 76,095 | 86,659 |

TABLE VII.—WORLD'S SULPHATE OF AMMONIA PRODUCTION.
(In metric tons of 2204.6 lb.)

| Country. | 1905. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|---|
| England | 273,550 | 294,170 | 318,400 | 330,450 | 354,747 | 373,590 | 391,260 | 385,700 |
| Germany | 190,000 | 235,000 | 287,000 | 313,000 | 330,000 | 373,000 | 418,000 | 492,000 |
| United States | 59,250 | 68,000 | 90,120 | 79,500 | 96,600 | 105,143 | 115,245 | 149,700 |
| France (*b*) | 47,300 | 49,100 | 52,700 | 52,600 | 53,600 | 56,000 | 60,000 | 68,500 |
| Belgium and Holland (*b*) | 24,200 | 30,000 | (*a*) 55,000 | (*d*) 35,000 | (*d*) 40,000 | (*d*) 43,000 | (*d*) 43,000 | (*d*) 50,000 |
| Spain (*b*) | 10,000 | 10,000 | (*c*) 12,000 | ..... | 12,000 | 9,000 | | |
| Italy (*b*) | 4,500 | 5,000 | 11,000 | (*d*) 80,000 | 12,000 | 12,000 | (*d*) 166,500 | 175,000 |
| Other Countries (*b*) | 40,500 | 40,000 | 65,000 | ..... | (*d*) 73,000 | (*d*) 79,000 | | |
| Total | 649,300 | 731,270 | 891,200 | 890,550 | 971,947 | 1,050,733 | 1,194,005 | 1,320,900 |

(*a*) Including Norway, Sweden and Denmark.
(*b*) Estimates from l'Engrais.
(*c*) Including Portugal.
(*d*) Estimates from Deutsche Ammoniak-Verkaufs-Vereinigung, 1908–9–10–11–12.

# ANTIMONY

In the past few years no antimony ore was mined in the United States, chiefly on account of the low price of both the metal and the ore. Several car-loads of ore are reported shipped in Utah, and successfully treated to recover the antimony contents. In 1912 the production of antimony apart from this was a by-product from lead refining.

The duty on metallic antimony imported is 1 1/2 cents per pound, and on antimony ore is 1 cent per pound on the antimony contents. Prices of the metal during 1912 showed an increase as in the following table:

AVERAGE MONTHLY PRICES OF ANTIMONY IN NEW YORK. (a)
(Cents per pound.)

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1904. | | | | | | | | | | | | | |
| Cookson's | 6.938 | 7.594 | 7.875 | 7.875 | 7.531 | 7.200 | 7.188 | 7.188 | 6.913 | 6.984 | 7.592 | 8.388 | 7.439 |
| Hallett's | 6.250 | 6.781 | 6.825 | 6.750 | 6.578 | 6.438 | 6.485 | 6.688 | 6.537 | 6.578 | 7.328 | 8.160 | 6.783 |
| Others | 5.688 | 6.203 | 6.475 | 6.406 | 6.203 | 5.961 | 5.969 | 6.062 | 6.015 | 6.172 | 7.204 | 8.088 | 6.371 |
| 1905. | | | | | | | | | | | | | |
| Cookson's | 8.375 | 8.375 | 8.375 | 8.219 | 8.406 | 11.025 | 12.625 | 14.500 | 13.700 | 13.000 | 12.500 | 14.000 | 11.100 |
| Others | 8.063 | 8.063 | 7.638 | 8.125 | 8.406 | 10.175 | 11.875 | 13.500 | 12.900 | 12.000 | 11.250 | 12.750 | 10.400 |
| 1906. | | | | | | | | | | | | | |
| Cookson's | 15.0 | 16.0 | 17.5 | 21.31 | 25.25 | 26.0 | 25.25 | 25.0 | 24.5 | 25.2 | 26.14 | 26.25 | 22.78 |
| Hallett's | 14.0 | 15.0 | 16.5 | 20.81 | 24.38 | 25.0 | 24.25 | 24.0 | 24.0 | 24.81 | 25.25 | 25.24 | 21.94 |
| Others | 13.5 | 14.25 | 16.15 | 20.25 | 23.31 | 24.0 | 23.19 | 22.75 | 22.25 | 23.63 | 24.50 | 24.70 | 21.73 |
| 1907. | | | | | | | | | | | | | |
| Cookson's | 25.906 | 25.062 | 24.90 | 24.125 | 21.937 | 15.75 | 11.875 | 10.906 | 10.75 | 11.75 | 11.00 | 9.662 | 16.969 |
| Hallett's | 25.219 | 24.062 | 23.75 | 21.344 | 18.562 | 13.812 | 10.50 | 9.687 | 10.00 | 10.406 | 9.937 | 9.05 | 15.527 |
| Others | 24.156 | 23.437 | 23.025 | 20.875 | 17.75 | 12.65 | 10.125 | 9.375 | 9.65 | 10.047 | 8.906 | 8.088 | 14.840 |
| 1908. | | | | | | | | | | | | | |
| Cookson's | 9.344 | 9.266 | 9.000 | 8.969 | 8.875 | 8.734 | 8.594 | 8.313 | 8.234 | 8.284 | 8.640 | 8.200 | 8.704 |
| Hallett's | 9.031 | 9.016 | 8.650 | 8.672 | 8.625 | 8.531 | 8.375 | 8.150 | 7.922 | 7.922 | 8.075 | 8.063 | 8.419 |
| Others | 8.344 | 8.406 | 7.988 | 8.297 | 8.250 | 8.094 | 8.125 | 7.850 | 7.609 | 7.625 | 7.775 | 7.688 | 8.004 |
| 1909. | | | | | | | | | | | | | |
| Cookson's | 8.202 | 8.125 | 8.047 | 8.250 | 8.387 | 8.312 | 8.375 | 8.525 | 8.687 | 8.537 | 8.437 | 8.437 | 8.360 |
| U. S. | 8.075 | 8.000 | 7.843 | 8.031 | 8.150 | 8.062 | 7.875 | 8.125 | 8.125 | 8.012 | 7.937 | 7.937 | 8.015 |
| Others | 7.675 | 7.531 | 7.500 | 7.718 | 7.887 | 7.893 | 7.375 | 7.625 | 7.506 | 7.500 | 7.687 | 7.687 | 7.466 |
| 1910. | | | | | | | | | | | | | |
| Cookson's | 8.500 | 8.469 | 8.359 | 8.438 | 8.438 | 8.241 | 8.175 | 8.278 | 8.313 | 8.263 | 7.922 | 7.625 | 8.252 |
| U. S. | 7.988 | 7.969 | 7.938 | 7.938 | 7.938 | 7.938 | 7.938 | 7.938 | 7.938 | 7.900 | 7.656 | 7.438 | 7.876 |
| Others | 7.738 | 7.578 | 7.313 | 7.438 | 7.438 | 7.438 | 7.400 | 7.328 | 7.313 | 7.400 | 7.188 | 7.063 | 7.386 |
| 1911. | | | | | | | | | | | | | |
| Cookson's | 8.25 | 8.38 | 9.56 | 9.54 | 9.50 | 8.75 | 8.50 | 8.44 | 8.31 | 8.14 | 7.97 | 7.78 | 8.59 |
| U. S. | 7.74 | 8.02 | 9.13 | 9.13 | 8.97 | | | 7.94 | 7.84 | 7.71 | 7.61 | 7.50 | 8.16 |
| Others | 7.5 | 7.65 | 9.00 | 8.52 | 7.99 | 7.42 | 7.35 | 7.36 | 7.26 | 6.96 | 6.92 | 6.82 | 7.54 |
| 1912. | | | | | | | | | | | | | |
| Cookson's | 7.53 | 7.27 | 7.65 | 8.05 | 8.02 | 8.09 | 8.42 | 8.59 | 9.12 | 10.30 | 10.39 | 10.21 | 8.90 |
| U. S. | 7.47 | 7.44 | 7.56 | 7.75 | 7.75 | 7.78 | 7.96 | 7.98 | 8.50 | 9.62 | 9.86 | 9.62 | 8.26 |
| Ordinaries | 6.88 | 6.83 | 6.86 | 6.94 | 7.10 | 7.21 | 7.50 | 7.70 | 8.26 | 9.30 | 9.30 | 9.18 | 7.76 |

(a) From *Eng. and Min. Journ.*

The following table gives the antimony statistics for the United States:

ANTIMONY STATISTICS OF THE UNITED STATES.
(In tons of 2000 lb.)

| Year. | Imports. | | Exports. | | Production. | | | Consumption. |
|---|---|---|---|---|---|---|---|---|
| | Metals or Regulus. | Ore. | Metal or Regulus. | Ore. | In Hard Lead. | From Domestic Ore. | From Imported Ore. (a) | |
| | Short tons | Short tons | Short tons | Short tons | Short tons | Short tons | Short tons | Short tons |
| 1899.... | 1,580 | 1,991 | *Nil.* | *Nil.* | 1,586 | 234 | 796 | 4,196 |
| 1900.... | 1,816 | 3,018 | 21 | *Nil.* | 2,476 | 151 | 1,207 | 5,638 |
| 1901.... | 1,837 | 866 | *Nil.* | 25 | 2,235 | 50 | 336 | 4,458 |
| 1902.... | 2,871 | 840 | 37 | 104 | 2,904 | *Nil.* | 294 | 6,032 |
| 1903.... | 2,563 | 1,337 | 40 | *Nil.* | 2,552 | *Nil.* | 535 | 5,610 |
| 1904.... | 2,028 | 1,245 | 16 | 214 | 2,515 | *Nil.* | 412 | 4,939 |
| 1905.... | 2,869 | 988 | *Nil.* | *Nil.* | 2,561 | *Nil.* | 395 | 5,825 |
| 1906.... | 3,950 | 1,124 | 12 | *Nil.* | 2,358 | 150 | 450 | 6,866 |
| 1907.... | 4,331 | 1,380 | 24 | 6 | 2,240 | 105 | 552 | 7,204 |
| 1908.... | 4,057 | 1,640 | 1 | 5 | 2,621 | 180 | 656 | 7,513 |
| 1909.... | 4,826 | 1,693 | 3 | *Nil.* | 2,546 | 38 | 694 | 8,055 |
| 1910.... | 4,950 | *Nil.* | *Nil.* | *Nil.* | 2,277 | 30 | *Nil.* | 7,257 |
| 1911.... | 5,479 | *Nil.* | *Nil.* | *Nil.* | 1,783 | *Nil.* | ..... | ..... |
| 1912.... | 6,969 | (b) 781 | *Nil.* | *Nil.* | 2,048 | *Nil.* | ..... | ..... |

(a) Estimated at 40 per cent. extraction from net imports of ore. (b) Antimony contents of 964 long tons of ore, containing less than 10 per cent. lead.

The production of antimony and antimony-oxide is made from imported materials, chiefly needle antimony from China. Antimony is also imported in the form of oxide as shown by the following table for fiscal years:

IMPORTS OF ANTIMONY OXIDE.

| | Pounds. | Dollars. |
|---|---|---|
| 1908..... | 709,662 | 73,667 |
| 1909..... | 595,095 | 65,596 |
| 1910..... | 414,713 | 20,407 |
| 1911..... | 942,616 | 50,371 |
| 1912..... | 1,079,268 | 46,671 |

Metallic antimony is imported to some extent from England, but mostly from Shanghai. Oxide is imported from France and regulus from Holland. Stibnite is also imported from England and France. The antimony contents of ore, regulus or metal remaining in warehouse after importation was 905,813 lb. valued $50,486 on Dec. 31, 1911; the same for Dec. 31, 1912, was 2,840,131 lb. valued $125,455.

The domestic producers of antimonial lead are the American Smelting & Refining Company, the Balbach Smelting & Refining Co., International Lead Co., and the United States Metals Refining Company. Secondary antimony from scrap is also produced by a few junk dealers.

The price of antimony-oxide rose from the beginning of the year, when it was 7 1/4 cents per pound, to 9 1/4 cents and to 10 1/2 cents per

pound at the end of the year. A good demand and high prices of the metal were responsible for this advance. The antimony oxide imported for consumption during 1912 was 1,759,908 lb. valued at $81,077 or 4.65 cents per pound.

The antimony contents of foreign ores, regulus or metal re-exported from the United States, was 160,844 lb. valued at $9737 in 1911, and 50,684 lb. valued at $2,766 in 1912.

*Notes on the Antimony Industry in Foreign Countries.*—The following table shows the production in recent years:

PRODUCTION OF ANTIMONY METAL IN FOREIGN COUNTRIES.
(In metric tons.)

| | 1900 | 1901 | 1902 | 1903 | 1904 | 1905 | 1906 | 1907 | 1908 | 1909 | 1910 | 1911 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Austria..... | 153 | 114 | 24 | 14 | 36 | 90 | *Nil.* | 207 | 162 | *Nil.* | *Nil.* | *Nil.* |
| China(b)..... | ..... | ..... | ..... | ..... | ..... | 3,353 | 3,829 | 2,316 | 9,356 | 7,937 | 6,643 | 6,986 |
| France..... | 1,600 | 1,786 | 1,725 | 2,748 | 2,116 | 2,396 | 3,433 | 3,945 | 3,850 | 5,444 | 4,640 | 4,775 |
| Hungary(a) | 846 | 706 | 683 | 732 | 1,007 | 756 | 1,322 | 841 | 670 | 695 | 782 | 892 |
| Italy..... | 1,174 | 1,721 | 1,574 | 905 | 836 | 327 | 537 | 610 | 345 | 59 | *Nil.* | *Nil.* |
| Japan..... | 349 | 429 | 528 | 434 | 321 | 190 | 627 | 248 | 198 | 157 | 120 | 97 |

(a) Regulus. (b) Exports of regulus and refined metal.

The antimony ore exports from Australia in 1912 were 30,894 cwt., valued at £25,548. The antimony and ore produced in New South Wales in 1911 were 165.5 tons, valued at £2010, and in 1912, 62.55 tons valued at £355. In 1911 20 tons of antimony ore valued at £92 were produced in New Zealand, but none was produced in 1910. During 1911 the Costerfield Mining Company, in Victoria, Australia, produced 743 tons of concentrates, assaying 45 per cent. antimony and 2 oz., 1 dwt. of gold per ton. This concentrate came from 1098 tons of ore and 6889 tons of old tailings, and was sold in England for £8928. The antimony mining industry in New South Wales is described by J. E. Crane.[1] He includes an account of the metallurgy of the uses of antimony ores.

The exports of antimony and antimony products from Belgium to the United States were valued at $58,902 in 1911, and $56,790 in 1912.

*China.*—The Chinese antimony production is the most important in the world. The exports of antimony ore as reported by the Inspectorate General of Customs, at Shanghai, is given in the table at the end of this volume. The figures for 1911 were 6812 tons of ore and 6986 tons of metal. In 1912 the exports are reported as 33,976 pikuls of ore and 223,656 pikuls of metal exported. The figures by provinces are given in the following table:

[1] Mineral Resources No. 16, Dept. of Mines, Geological Survey of New South Wales, 1912.

CHINESE ANTIMONY PRODUCTION.
Long Tons.

| | Canton. | Wuchow | | Yuenow. | | Changsha. | | |
|---|---|---|---|---|---|---|---|---|
| | Ore. | Ore. | Regulus. | Ore. | Crude. | Ore. | Crude. | Regulus. |
| 1900 | | 237 | | | | | | |
| 1901 | | 71 | | | | | | |
| 1902 | | | | 300 | 1795 | | | |
| 1903 | | | | 2435 | 4554 | | | |
| 1904 | 473 | | | 1370 | 3245 | 224 | 851 | |
| 1905 | 261 | | | 340 | 1457 | 1774 | 1679 | |
| 1906 | 292 | | | 1199 | 733 | 2271 | 2375 | |
| 1907 | 504 | | | 2755 | 646 | 3092 | 1751 | |
| 1908 | 142 | | 3 | 1128 | 1903 | 553 | 5956 | |
| 1909 | 51 | 41 | ½ | 1964 | 974 | 1101 | 5542 | 240 |
| 1910 | 5 | 115 | 19 | 2190 | 930 | 1289 | 7147 | 803 |
| 1911 | 64 | 48 | 356 | 744 | 2874 | 501 | 7245 | 1566 |
| 1912 | 275 | 54 | 232 | 1214 | 373 | 680 | 5386 | 2012 |

The crude antimony exported to the United States in 1910[1] was $55,379, and in 1911, $80,516. The refined and regulus from Hankow to the United States, was valued $37,313 in 1910 and $116,458 in 1911. The domestic antimony exported from Hankow, China, in 1911, was 571,067 lb. valued at $15,076. The total antimony shipments increased in value from $92,692 in 1910 and to $196,974 in 1911, of which $116,458 represented the refined metal and regulus. The total shipments to Chinese and foreign ports were $505,645, exclusive of ore. This antimony comes from Hunan Province. The antimony industry of China is described in a book on "Antimony."[2]

The antimony refining works at Shanghai increased its output of regulus from about 100 to 300 tons a month. W. E. Schoeller[3] states the following: At Shanghai and other places in the province, crude antimony is obtained by liquation. Each furnace holds two clay crucibles, perforated at the bottom and inclined. Fifty pounds of charge in each crucible is heated for two hours, the liquated metal being ladled into molds. The pasty residue is thrown into iron frames and forms a cake. The Chinese estimate the value of ore by putting a hundred pound sample through this process disregarding the antimony in the residues. A yield of 70 per cent. crude by this method corresponds to an actual antimony content of 50 per cent. The residue carries 26 per cent. antimony.

High grade ore from Hunan usually runs 58 per cent.; arsenic seldom exceeds 1/10 per cent.; and lead, copper and zinc, 0.05 per cent.; iron, 0.5 per cent. These are remarkably pure ores. In estimating the antimony by the Chinese method, it was noticed that these ores often give a percentage slightly in excess of 71.43 per cent., which is demanded

[1] Daily Cons. and Tr. Rep., January 4, 1913.
[2] By C. Y. Wang, Charles Griffin & Co., London, 1909; also *Eng. and Min. Journ.*, Oct. 26, 1912, p. 777.
[3] Paper before "Society of Chemical Industry," March 3, 1913.

by $Sb_2S_3$. To determine whether the sulphur was deficient, that is, whether part of the antimony was present in excess, two samples of crude were found to analyze as follows:

| | Crude. | | Regulus. Per cent. |
|---|---|---|---|
| | Sample I. Per cent. | Sample II. Per cent. | |
| Antimony | 71.60 | 71.70 | 98.20 |
| Arsenic | 0.069 | 0.048 | 0.148 |
| Iron | 0.821 | 0.14 | 0.146 |
| Copper | 0.015 | not determined | 0.025 |
| Lead | 0.011 | not determined | 0.006 |
| Zinc | 0.071 | 0.02 | 0.025 |
| Insoluble | 0.408 | 0.24 | 0.076 |
| Sulphur | 21.60 | 24.92 | 0.370 |
| Total | 94.595 | 97.068 | 98.996 |

The deficiencies in these results may be caused by the presence of oxygen.

France is the second producer of antimony. The exports declared from Havre, France, to the United States were valued at $58,829 in 1911, and $86,735 in 1912. Most of the refining of antimony of other than French ores and metal is done in England. It has been suggested that France should be a larger competitor, say at Havre, where the metal comes directly from the Orient. The exportation of antimony ores from Tonkin has been reported as 328 tons for the first half of 1912.

Italy in 1911 had three works treating antimony ore, and the production was 2194 tons valued at 149,769 lires in 1910, and 2441 tons valued at 81,644 lires in 1911. Japan is probably the third producer of antimony ores. Antimony exported to the United States was declared at a value of $66,918 in 1911 and $62,734 in 1912.

Mexican production in the form of mattes is chiefly treated by the American Smelting Refining Company. The matte from the Metallurgica Nacional contains 0.12 per cent. antimony, whereas the mattes from the Hidalgo run as high as 24.12 per cent.[1]

The antimony oxide[2] produced from San Luis Potosi, Central Mexico, was valued at $195 in 1911 and $1528 in 1912. Antimony is derived from a short stretch between Charcas and Catorce. The antimony smelter at Wadley, the only one in the Republic of Mexico, is controlled by British capital and its product goes to Newcastle-on-Tyne to be handled by the Cooksons. The antimony territory consists of a strip 14 miles long, north and south of Catorce; it lies in blue limestone, tilted at many angles, and with porphyry contacts plainly visible. The ore is found in the porphyry and runs from 5 to 55 per cent. metal, consisting

[1] *Eng. and Min. Journ.*, Feb. 1, 1913, p. 203.
[2] Div. Consln. and Tr. Rep., March 18, 1913.

of oxides and sulphides. The output is approximately 4000 tons per annum.

The exports of antimony from Mexico were valued at 1,873,965 pesos for the year 1910, and 1,728,338 pesos in 1911.

In South America the fine antimony produced in Peru was 20.1 tons in 1909, and 48.7 tons in 1910. Bolivia produced 524,878 kg. in 1910, and 90,000 kg. in 1911. The record production of 60 per cent. ore occurred in 1908, when it was said to be about 1,000,000 kg. exported. Spain has one mine producing antimony ore. In 1911 the production was 100 tons valued at 10,000 pesetas. The last official report from Turkey states the production of antimony ore as 621 metric tons valued £15,761, for the fiscal year ending in March, 1908. The United Kingdom produced no antimony ore since 1892. The export of antimony and regulus to the United States from the United Kingdom during 1910, was valued at $328,182, and during 1911 at $280,801. The antimony smelters and refiners are the following: Antimony Recovery Syndicate, Ltd., Runcorn; Cookson & Co., Ltd., Willington Quay; Hallett & Fry, London; Johnson, Matthey & Co., Ltd., London & Patricroft; Magnesium Metal Co., Patricroft; Pratt, J. J., & Son, London; Roddick, Alfred & Co., London; St. Helens Smelting Co., Ltd., St Helens.

*Production of High Antimony Speiss in Recovering Gold and Silver.*—This speiss was obtained in the course of treatment of mattes from smelting concentrates, roasted concentrates, and copper ore, by G. C. McMurtry.[1] The copper ore was the only source of sulphur available free from As and Sb. The arsenic and Sb in the concentrates were from 14 to 20 per cent. and 1.4 to 3.7 per cent. respectively. After calcining and smelting the speiss was precipitated from the regulus which was mined from the furnace over scrap wrought iron on sand beds. Formerly a 12 per cent. Cu matte gave a speiss not precipitated by iron as shown in No. 1. Numbers 2 and 3 are from 32 per cent. and 34 per cent. mattes precipitated by iron. These mattes ran 1.56 Sb and 0.45 As.

ANALYSES OF SPEISSES.

| | No. 1. Per cent. | No. 2. Per cent. | No. 3. Per cent. |
|---|---|---|---|
| Sb | 41.82 | 42.25 | 52.26 |
| As | 18.56 | 4.90 | 4.51 |
| Cu | 7.78 | 22.44 | 18.90 |
| Fe | 10.20 | 5.39 | 5.20 |
| Ni | 6.57 | 9.80 | 10.30 |
| Pb | 2.94 | 9.42 | 5.30 |
| Au | 2.60 | } 3.48 | 3.60 |
| Ag | 0.02 | | |
| S | 1.72 | 2.18 | 1.05 |
| Ca | 0.85 | ..... | ..... |
| $SiO_2$ | 0.63 | ..... | ..... |
| Undetermined | 6.31 | ..... | ..... |

[1] *Bull. 97, Inst. Min. and Met.*

The speiss No. 3 varied from bright appearance near the tap hole to the dull, lower in the bed, as follows:

| | Bright. Per cent. | Dull. Per cent. |
|---|---|---|
| Antimony | 38.48 | 26.25 |
| Arsenic | 5.26 | 3.02 |
| Copper | 14.40 | 31.50 |
| Gold (ounces per ton) | 1979 | 771 |

After granulating and smelting, the product was remelted with copper ore, the No. 3 giving a 22 per cent. copper matte low in gold and the following speiss: Sb, 59.42 per cent.; As, 10.12 per cent.; Cu, 4.40 per cent.; Ni, 12.60 per cent.; Fe, 0.77 per cent.; Pb, 0.10 per cent.; S, 2.70 per cent.; Au, Ag 10.00 = 3266 oz. per ton. This was then cupelled with lead to recover the precious metals.

*Sensitiveness of Stibnite to Light.*—Some years ago M. Jaeger observed that stibnite, like selenium, was sensitive to light. An advantage of stibnite would appear to be the superior sensitiveness, that is, absence of inertia and as soon as the light is interrupted the electrical resistance decreases to what it was before. The mineral pulverized loses the property. According to Messrs. Olie and Kruyt[1] artificial $Sb_2S_3$ can be prepared of such purity that the sensitiveness is equal to that of natural stibnite. The electrical conductivity increases from the value 100 to 500 by the action of light.

*Recovery from Stibnite.*—The separation of antimony from stibnite in the electric vacuum furnace is accomplished by Dr. Fink.[2] Iron or a mixture of calcium oxide or carbon is employed. The antimony is reduced at a lower temperature and then distilled at a temperature from 900 to 1250.[9]

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[1] *Revue Scientifique*, Oct., 1912.
[2] *Eighth International Congress of Applied Chemistry.*

# ARSENIC

The domestic production of arsenic (arsenious acid or white arsenic) from information furnished by the producers in the United States, was 2926 tons in 1912, as compared with 3081 tons in 1911, and 1526 tons in 1910. The growth of the domestic arsenic production during the last 5 years, is to some extent due to the enactment of laws compelling western smelters to condense the arsenic contained in the fume. The market has been stimulated, and the consumer is now practically independent of the European market. This is indicated by the table of imports for fiscal years ending in June:

WHITE ARSENIC IMPORTS

| | 1910. Pounds. | 1911. Pounds. | 1912. Pounds. |
|---|---|---|---|
| Austria-Hungary | 22,046 | ..... | ..... |
| Belgium | 324,859 | 109,005 | 370,859 |
| France | 1,180 | ..... | ..... |
| Germany | 1,822,005 | 1,875,045 | 1,293,480 |
| Portugal | 46,938 | ..... | ..... |
| Spain | 112,106 | ..... | ..... |
| United Kingdom, England | 1,410,110 | 54,921 | 226,903 |
| Canada | 1,902,359 | 2,865,131 | 2,956,054 |
| Mexico | 824,459 | 2,120,008 | 476,854 |
| Totals | 6,466,062 | 7,024,110 | 5,324,150 |

Arsenious-acid is imported free. The imports during the calendar year 1912, were 6,205,562 lb. valued at $200,616. This is independent of the arsenic, metallic sulphide or orpiment imported additionally.

The imports of these were 8,257,474 lb. valued $251,716 in 1910; 5,404,263 lb. valued $159,626 in 1911, and 6,758,946 lb. valued $246,815 in 1912. The average values per lb. were, therefore, 3.1, 2.95, 3.65 cents in three years respectively.

The distribution centers of arsenic are moving westward, largely on account of the market for insecticides. The domestic market is also supplied from Mexico and Canada. In the United States, the Anaconda Arsenic Plant was understood to be closed down, and the American Smelting & Refining Company and the United States Smelting Company during 1912 curtailed their productions. In addition to these producers some of the large acid-makers are said to be marketing arsenious sulphide recovered from the preparation of arsenic-free sulphuric-acid. In Canada, the Deloro Mining & Reduction Company, Deloro, Ont., and the Coniagas Reduction Company, St. Catherines, Ont., are the only

producers. The Canadian Copper Company has announced its withdrawal from arsenic manufacture. In Mexico, the Compania Minera Penoles, Mapimi, Mexico, was working its plant on flue-dust as in previous years. The production has not been reduced and was probably in the neighborhood of 2000 tons.

*Markets.*—The prices at the beginning of 1912 opened low at about 1 1/8 to 2 cents per pound. Both producers and dealers were discouraged. In March the prices had risen to 2 3/4 to 3 3/4 cents per pound for white arsenic. The apparent oversupply was due to the liquidation of large speculative stocks which were unloaded eventually at any price obtainable, while the actual production had been passed by consumption. The prices rose into 1913. The same group which had unloaded its stocks before, came into the market in July and September with a price of 4 3/4 cents or higher.

The uses of the arsenic product are chiefly as an insecticide, in the form of paris green or lead arsenate. About 63 tons of paris green were imported in 1911, at 4 cents per pound.[1] It is understood that the Grasselli Chemical Company is the largest producer of lead arsenate in the United States. The Merimac Chemical Company is also a producer.

STATISTICS OF WHITE ARSENIC IN THE UNITED STATES.

| Year. | Production. | | | Imports. | | | Consumption. | |
|---|---|---|---|---|---|---|---|---|
| | Pounds. | Value. | Per lb. | Pounds. | Value. | Per lb. | Pounds. | Value. |
| 1899 | ..... | ..... | ..... | 9,040,871 | $386,791 | $0.04¼ | 9,040,871 | $386,791 |
| 1900 | ..... | ..... | ..... | 5,765,559 | 265,500 | 0.04¼ | 5,765,559 | 265,500 |
| 1901 | 600,000 | $18,000 | $0.03 | 6,989,668 | 316,525 | 0.04½ | 7,589,668 | 334,520 |
| 1902 | 2,706,000 | 81,180 | 0.03 | 6,110,898 | 280,055 | 0.04½ | 8,816,898 | 361,235 |
| 1903 | 1,222,000 | 36,691 | 0.03 | 7,146,362 | 256,097 | 0.03½ | 8,368,362 | 292,785 |
| 1904 | 996,456 | 29,504 | 0.03 | 6,391,566 | 226,481 | 0.03½ | 7,388,022 | 255,988 |
| 1905 | 1,545,400 | 50,225 | 0.03¼ | 6,444,083 | 219,198 | 0.03½ | 7,989,483 | 269,425 |
| 1906 | 1,663,000 | 83,150 | 0.05 | 7,639,507 | 336,609 | 0.04½ | 9,302,507 | 419,753 |
| 1907 | 2,020,000 | 101,000 | 0.05 | 9,922,870 | 553,440 | 0.05½ | 11,942,870 | 654,449 |
| 1908 | 2,603,505 | 99,193 | 0.03⅜ | 9,592,881 | 417,137 | 0.04¼ | 12,196,387 | 516,330 |
| 1909 | 2,015,880 | 57,957 | 0.02⅞ | 7,183,644 | 272,493 | 0.03¾ | 9,199,524 | 330,450 |
| 1910 | 2,652,000 | 66,300 | 0.02½ | 8,204,123 | 250,115 | 0.03 | 10,856,123 | 316,410 |
| 1911 | 6,162,000 | 123,240 | 0.02 | 6,916,069 | 203,766 | 0.02⅞ | 13,078,069 | 327,006 |
| 1912 | 5,852,000 | 204,820 | 0.03½ | 6,205,562 | 200,616 | 0.03¼ | 12,057,562 | 405,436 |

The Brinton arsenic smeltery, at Brinton, Floyd County, Va., was described in MINERAL INDUSTRY, Vol. XX, p. 48, but as far as known was not in regular operation. It was intended to manufacture paris green and other insecticides from the product of this mine at Norfolk, Va.

The manufacture of arsenic and the plant for recovering fume, at the Midvale plant of the United States Smelting Company in Utah, was described in MINERAL INDUSTRY, Vol. XIX, p. 44, and Vol. XX, p. 49.

[1] In 1912 the imports of paris green and London purple were 81 tons valued 4.3 cents per pound. The duty is 15 per cent.

According to the United States Geological Survey Report, Paper No. 70, the arsenic in the Washoe Works, Anaconda, originates in the enargite. Of this mineral, 3.3 to 5.5 per cent. are recovered in the flue-dust, 22,000 lb. of which are collected daily. This figures 11 to 18 tons of arsenic per month. As estimated last year, in 1911, the amount of arsenic recovered increased four times over 1910.

The deleterious fumes from a smeltery such as the Murray plant of the A. S. and Ref. Co., contain much arsenic, lead and other sulphates, and to prevent injury to farm lands a baghouse is installed. Similarly at the Omaha plant a number of baghouses are in use.[1]

At the Murray plant in 8 months during which 254,794 tons of charge were smelted, 1124 tons of fume were produced. The extraction of $As_2O_3$ from the fumes, after burning is done at another plant where there is an arsenic establishment. It is stated that with this equipment at Murray the cost of working up the fume would not exceed $5 per ton. In spite of a loss for operating the baghouse it is considered good business to operate the same for the protection of the farmer's and to prevent lawsuits. The assay of the fume is as follows:

| | Unburnt. | Sintered. |
|---|---|---|
| Ounces, Au | 0.0149 | 0.014 |
| Ounces, Ag | 2.62 | 2.4 |
| Per cent., Pb | 28.42 | 27.3 |
| Per cent., Cu | 0.058 | 0.05 |
| Per cent., $SiO_2$ | 2.9 | 2.5 |
| Per cent., Zn | 3.2 | 4.2 |
| Per cent., S | 5.2 | 4.2 |
| Per cent., As | 36.6 | 33.5 |
| Per cent., Fe | 5.1 | 5.2 |

The raw fume at the Omaha plant assayed:

| | |
|---|---|
| Pb | 52.5 per cent. |
| Zh | 3.0 per cent. |
| S | 5.4 per cent. |
| As | 14.2 per cent. |
| Sb | 1.6 per cent. |
| Ag | 10.0 ounces. |

The fume contains much carbon and $As_2O_3$ and occasionally it ignites spontaneously and shrinks considerably in bulk. In sintering, the arsenic not already present as $As_2O_3$ is oxidized and a portion volatilized. The fume sinters lightly and assumes the structure of coke. The arsenic is recovered in beautiful white crystals. It is concentrated to about 20 per cent.

Experiments made on roasting burnt fume without fusion to see how far the arsenic could be eliminated gave a reduction from 13.1 per cent. to 3.7 per cent. As. The burnt fume carrying 18 to 20 per cent.

[1] A. Eilers, *Eighth Int'l. Cong, Appl. Chem.*

arsenic and 2 per cent. antimony, is fused in a small reverberatory furnace and the gases led to a 300-ft. stack. This gives a slag, a mixture of the oxides of Pb, Sb and As; the arsenic being 5 per cent. The market does not warrant the necessary expenditure to recover very pure arsenic at this point. The fused material is cooled in pots and charged into the residue furnace of the lead refinery, the silver (10 oz.) going into the lead reduced. The "Smoke" slag from this operation contains 5 to 6 per cent. antimony and 3 to 4 per cent. arsenic. The arsenic is removed by a special process of fusion, since the metal that would be obtained in a blast-furnace with lead skimmings is too high in arsenic and less than 10 per cent. antimony, and unsuitable for antimonial lead.

*Arsenic Contents of Mine Products.*—The cake of washed residue produced at the Nipissing High Grade Mill,[1] consists largely of cobalt and nickel arsenides; one analysis shows 29.50 per cent. arsenic. Complete analysis is given under "Nickel and Cobalt." A general analysis of impure Mexican mattes is given by P. S. Harrison.[2]

Those from the Metallurgica Nacional, contain arsenic 0.31, antimony 0.1250, sulphur 24.5 and iron 23.6 per cent. Those from the Hidalgo run: sulphur 5 per cent., arsenic 7.9 per cent. and antimony 24.12 per cent.

*Analysis.*—A method has been evolved in the laboratory of the General Chemical Company for determining arsenic and based on the Gutzeit test.[3] The Marsh test is tedious and obsolete. Correct results with the new method depend on the presence of ferrous and stannous salts.

The estimation of arsenic and antimony is described by Harley E. Hooper.[4]

*Use in Window Glass.*—Arsenic is also used in the manufacture of window glass. When used in excess for this purpose, it produces an objectionable milky color which increases with age. The function of the arsenic is to act on the carbonaceous material destroying it.

*Elimination of As.*—Experiments have been made by Dr. Colin G. Fink, of the General Electric Company, Harrison, N. J., on the treatment of smaltite ores from Canada, in the electric vacuum furnace.[5] Up to 1500° C., only 40 per cent. of the arsenic is expelled from the ore. Effect of additions such as calcium carbide, is to eliminate the arsenic, leaving in one case only 2.1 per cent. arsenic. Calcium arsenide separates as a slag, and part of the arsenic volatilizes.

Nipissing ore containing 28.65 per cent. arsenic, behaves in a similar manner. Treated according to United States patent 996,479, three layers easily separated upon cooling, are obtained.

[1] R. B. Watson, *Eng. and Min. Journ.*, Dec. 7, 1912.
[2] *Eng. and Min. Journ.*, Feb. 1, 1913, p. 283.
[3] W. S. Allen and Ralph M. Palmer, *Eighth Intl. Cong. Appl. Chem.*
[4] *Eng. and Min. Journ.*, Oct. 12, 1912, p. 706.
[5] *Eighth Intl. Cong. Appl. Chem.*

*Notes on the Foreign Asenic Industry.*—In Belgium two factories connected with lead works, produce arsenic from the residues obtained in smelting lead ores. The total output of 2500 tons, is sent mostly to Germany (460 tons in 1911), to Great Britain and the United States. The value of the arsenic declared for export to the United States was $18,452 in 1911 and $37,021 in 1912. Canada produced 2045 short tons of white arsenic in 1912, valued at $88,726, as compared with 2097 tons in 1911. In China, mines of orpiment exist in Talifu, Yuman. In 1909, 491 short tons of mineral were shipped from Siakwan through Teng Yueh, to Burma. The exports in 1910 were 600 tons valued $51,504, and in 1911, 366 tons valued $23,145. From France the first meeting of the society called "L'arsenic" was scheduled for 1913 at Paris. One of the principal mines in France mining arsenical-pyrites, treated about 97 tons during the calendar year 1911, from which 157,500 kg. of arsenious acid were recovered. The Realgar mine of Matra, Corsica, is being developed and is reported to contain pure mineral of 55 to 60 per cent. arsenic content. It is estimated that 40,000 tons are in sight, and the deposit is unique. The vein is in some places 13 ft. in thickness. The arsenic market at the present time is regulated by the supply of mispickel. It requires an expensive process to change to colored pigments. Japan produced in 1911, 5,760 kg. of arsenic, and in 1910 11 1/2 tons of arsenic ore. The production of the Nagasaki district is reported as 12,672 lb. of arsenic valued at $382 in 1911.[1]

In Italy the arsenic ore produced in 1910, was 16 tons, but none has been reported since. The exports from Mexico being arsenious acid from Durango to the United States, was valued at $88,298 in 1910, and $33,098 in 1911. In Norway the Liestulli mine is worked by the Christiania Minekompagni. The ore is mispickel, containing an average of 32 per cent. arsenic. About 1000 tons of lump ore have been exported. A concentrated product of 52 per cent. arsenic is expected to be made. In Spain the production of two mines was 1056 tons valued at 17,952 pesetas at the mine.

In Portugal the Pintor mine produces arsenical pyrite. The arsenic produced is 95 per cent. pure $As_2O_3$. In 1911, 50 Pengilly furnaces, one reverberatory and one Oxland furnace were in operation.

Most of the arsenical pyrites produced in the United Kingdom came from the Consolidated Tamar mines in Cornwall. In addition arsenic is obtained by calcination at a number of the mines.

In 1911, the former product amounted to 1150 tons of ore valued at £1260, and the latter for the United Kingdom, amounted to 2144 tons d at £114,413. The arsenic refiners in the United Kindgom are

[1] Cons. and Tr. Rep., Oct. 14, 1912.

the following: Bissoe Tin Smelting & Arsenic Co., Ltd., Bissoe (Kea); British Mining & Metal Co., Ltd., Coombe; Cornwall Arsenic Co., Bissoe Bridge; Portreath, Redruth, English Arsenic Co., Gwithian; Trythall, W. J., Bissoe, (Kea); Bayldon, E. H., Stromsdown Mines, Ashburton; and Friednship Mines, Marytavy; Consolidated Tarmar Mines, Ltd., Rumleigh; John Bevan & Son, Ltd., Port Tennant, Swansea.

WORLD'S PRODUCTION OF ARSENIC.
(In metric tons.)

| Year. | Canada. (a) | Germany. (b) | Italy. (d) | Japan. (a) | Portugal. (d) | Spain. (b) | United Kingdom. (a) | United States. (a) | France. (d) |
|---|---|---|---|---|---|---|---|---|---|
| 1898..... | *Nil.* | 2,677 | 215 | 7 | 751 | 111 | 4,241 | ..... | ..... |
| 1899..... | 52 | 2,423 | 304 | 5 | 1,083 | 101 | 3,890 | ..... | 2,600 |
| 1900..... | 275 | 2,414 | 120 | 5 | 1,031 | 150 | 4,146 | ..... | 4,705 |
| 1901..... | 630 | 2,549 | ..... | 10 | 527 | 120 | 3,416 | 272 | 7,491 |
| 1902..... | 726 | 2,828 | ..... | 12 | 736 | 71 | 2,165 | 1,226 | 5,372 |
| 1903 ..... | 233 | 2,768 | 50 | 6 | 698 | 1,088 | 916 | 554 | 6,658 |
| 1904..... | 66 | 2,829 | 80 | 4 | 1,370 | 400 | 992 | 452 | 3,117 |
| 1905..... | *Nil.* | 2,535 | ..... | 8 | 1,562 | 1,140 | 1,552 | 701 | 3,627 |
| 1906..... | *Nil.* | 3,052 | .. .. | 5 | 1,322 | 1,114 | 1,625 | 754 | 6,534 |
| 1907..... | 317 | 2,904 | 73 | 7 | 1,538 | 2,400 | 1,523 | 916 | 7,900 |
| 1908..... | 649 | 2,822 | 451 | 20 | 1,655 | 2,004 | 2,007 | 1,301 | 2,381 |
| 1909..... | 1,020 | 2,911 | *Nil.* | 8 | 1,420 | 506 | 2,911 | 914 | 2,141 |
| 1910..... | 1,363 | 3,066 | *Nil.* | 12 | 974 | 444 | 2,187 | 1,203 | 8,045 |
| 1911..... | 1,902 | 2,981 | 16 | 6 | 887 | 331 | 2,178 | 2,800 | 19,000 |
| 1912..... | 1,850 | ..... | *Nil.* | ..... | 1,006 | (c) | 2,228 | 2,650 | (c) |

(a) White arsenic. (b) Oxide, sulphide, etc. (c) Not yet available. (d) Ore.

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# ASBESTOS

No progress in the mining of asbestos can be reported for the United States in 1912. The country is the largest consumer of this product, but the increasing demand is supplied by increasing imports, chiefly from Canada. The latter country is the chief source of asbestos for the world.

The tonnage produced in the United States in 1912 was only 4403 short[1] tons as compared with 7604 tons in 1911. The value, owing to a larger proportion of fiber, was increased per ton and fell short of the total in 1911 about 30 per cent., being $87,959.

Prices were affected in the early part of 1912 by the fact that large stocks of both crude and fiber were accumulated in 1911 and thrown on the market, at low figures. These stocks were consumed later. A factor in this market is the European demand; the tendency for a larger market in this direction is felt in the American prices advancing. Not only crude but also manufactured products are imported into the United States in increasing quantity; the import duty varied from 40 per cent. on woven fabric to 25 per cent. on other manufactures. The export of domestic asbestos manufactures, however, far exceeds the imports in value and quantity and considering the home consumption the industry is prosperous. The production and imports are shown in the following table:

ASBESTOS STATISTICS OF THE UNITED STATES.

| Year. | Production. | | | Imports. | | |
|---|---|---|---|---|---|---|
| | Short Tons. | Value. | Value per Ton. | Manufactured. | Unmanufactured. | Total. |
| 1899..... | 912 | $ 13,860 | $15.20 | $ 8,946 | $ 303,119 | $ 312,068 |
| 1900..... | 1,100 | 16,500 | 15.00 | 24,155 | 331,796 | 355,951 |
| 1901..... | 747 | 13,498 | 18.08 | 24,741 | 667,087 | 691,828 |
| 1902..... | 1,010 | 12,400 | 12.27 | 33,313 | 729,421 | 762,734 |
| 1903..... | (a) 887 | (a)16,760 | (a)18.90 | 32,058 | 657,269 | 689,327 |
| 1904..... | (a)1,480 | (a)25,740 | (a)17.40 | 51,290 | 700,572 | 751,862 |
| 1905..... | 3,100 | 126,300 | 40.74 | 70,117 | 776,362 | 846,479 |
| 1906..... | (a)1,695 | (a)28,565 | (a)16.85 | 96,162 | 1,010,453 | 1,106,615 |
| 1907..... | 950 | 11,700 | 12.32 | 200,371 | 1,104,110 | 1,304,481 |
| 1908..... | 1,350 | 24,000 | 17.78 | 147,548 | 1,068,342 | 1,215,890 |
| 1909..... | 4,025 | 87,625 | 21.77 | 240,381 | 993,254 | 1,233,635 |
| 1910..... | 3,630 | 64,350 | 18.80 | 308,078 | 1,235,170 | 1,543,248 |
| 1911..... | (a)7,604 | (a)119,935 | (a)15.77 | 290,098 | 1,413,541 | 1,703,639 |
| 1912..... | (a)4,403 | 87,959 | 19.97 | 363,759 | 1,465,012 | 1,819,771 |

(a) Statistics of the United States Geological Survey.

[1] S. Diller, "Mineral Resources," Advance Chapter, *U. S. Geol. Surv.*, 1913.

The imports of manufactured asbestos were: 1909, 41,524 long tons; 1910, 52,797 long tons; 1911, 62,418 long tons; 1912, 63,860 long tons; the import prices have remained fairly constant. In 1912 the manufactured imports were in part $93,300 for woven fabrics.

The exports of domestic manufactured asbestos in 1912 were valued at $625,328.

The exports of raw asbestos from the United States to the United Kingdom during the year 1910 were valued at $35,807, and during the year 1911 were valued at $17,947.

Four-fifths of the exports from Canada were into the United States; this quantity being two-thirds of the Canadian production.

The value of asbestos exported from Hungary through Budapest to the United States in 1910 was $31,035; in 1911, $11,973.

The exports from Antwerp, Belgium, of asbestos, to the United States, amounted during the year 1911 to $14,737, and during the year 1912, $25,122.

## Mining in the United States

According to the Bureau of the United States Census, twenty mines, employing 88 persons, expended in 1909 $72,747 for development and operation, which exceeds the value of the products mined in that year, as reported by the Bureau.

The States in which asbestos was mined in 1912 are Vermont, Wyoming and Georgia. Vermont has long been the chief producing state. In 1912 one company in this state was able to produce more than three-fourths the total production of the country. The Lowell Lumber and Asbestos Company, now the Chrysotile Asbestos Corporation, was an active producer though its production was not increased over that of 1911 on account of a shut down for lack of labor for three months in the spring of 1912. Many shipments from the mines of this company go directly to Austria and countries nearby. During the last calender year, however, on account of the war with Turkey, many manufactories were compelled to shut down and the shipments from the United States were deferred. The company proposes to erect a plant to treat asbestos when it cannot be used in the crude state. This will open up a larger field for the fiber which is to be processed. The corporation has taken over Mr. John F. Green's process for eliminating the free magnesia which carries with it the iron oxides in the processed asbestos fiber; this method of treatment produces a successful product which has stood the practical test for insulation. The purified material can be used mixed with grades No. 4 or 5, these being from 40 to 90 per cent. depending on requirements.

The waste powder in dumps is to be recovered and treated, making a product of higher prices than Nos. 2 and 3.

The National Asbestos Co. of Chicago is to exploit an asbestos deposit 20 miles from Llano, Texas; the outcrop is 250 ft. by 1600 ft. and the deposit is of the chrysolite variety. The locator was N. J. Badu who sold to the company.

Wyoming asbestos comes from two localities: Caspar Mountain and Smith Creek. The development of these localities is limited on account of lack of transportation facilities. Financial difficulties also have delayed operations. The asbestos was shipped to the factory of the International Asbestos Company in Denver. It is understood that these companies, including the Northwestern Asbestos Co. and the Asbestos Mills and Power Co., are now to cooperate and the industry is to be expanded.

## Foreign Countries

*Canada.*—The history of asbestos holdings in Canada in 1912 is given by W. J. Woolsey.[1] The existing owners are shown as follows: in Thetford, Martin-Bennett Asbestos Co., Keasbey & Mattison, Asbestos Corporation, Jacobs Asb. Co.; in Black Lake the Asbestos Corporation, Johnson's Company, Consolidated Asbestos Co.; in Danville, the Asbestos Asbestic Company.

The production of asbestos and asbestic in Canada for 1912 was 106,520 short tons valued at $29,596,677 and 24,740 short tons valued $19,707. In 1911 corresponding figures were 101,393 tons and $2,922,062 for asbestos and 26,021 tons and $21,045 for asbestic. The productions therefore were in accordance with the sales as given in detail below 131,260 short tons for 1912 and 127,414 tons in 1911. The discrepancies between Federal figures and those of the Quebec are accounted for by different methods of considering the product from rock milled, the shipments and the sales.

The total shipments of asbestos in 1912 exceeded those of 1911 by at least 5 per cent., it being probable that complete returns will show a somewhat higher production and shipments than the figures given below. According to returns so far received, the total output of asbestos was 97,816 tons, the sales 106,520 tons, valued at $2,959,677, or an average of $27.79 and stock on hand at the end of the year amounting to 21,686 tons, valued at $1,021,066. The record indicates an increase in sales [illegible]tion of stocks on hand.

[illegible] were confined to the mines of the Black Lake and Thetford

[1] Vol. XXXIII, Nov. 1, 1912, p. 745.

districts, those at East Broughton remaining idle. Operators report that they were handicapped by shortage of labor but since market prices and conditions have greatly improved, 1913 promises to be a very successful year. The number of men employed in mines and mills during 1912 was 2755, at a wage cost of $1,296,655. The total quantity of asbestos rock sent to mills is reported as 1,514,314 tons, which, with a mill production of 97,815 tons, shows an average estimated recovery of about 6.45 per cent.

The following tabulated statement shows the output and sales during 1912, and the stock on hand at the end of the year.

| | Output. | Sales. | | | Stock on Hand Dec. 31. | | |
|---|---|---|---|---|---|---|---|
| | Short Tons. | Short Tons. | Value. | Per Ton. | Short Tons. | Value. | Per Ton. |
| | | | $ | $ | | $ | $ |
| Crude No. 1 | 1,447½ | 1,928.9 | 507,904 | 263.31 | 864.8 | 220,789 | 255.31 |
| Crude No. 2 | 3,224 | 3,669.0 | 372,357 | 101.49 | 2,719.0 | 293,263 | 107.86 |
| Mill stock No. 1 | 19,672 | 18,758.0 | 843,559 | 44.97 | 7,490.0 | 338,069 | 45.13 |
| Mill stock No. 2 | 35,389 | 43,359.0 | 855,902 | 19.74 | 6,278.0 | 132,349 | 21.08 |
| Mill stock No. 3 | 38,083 | 38,805.0 | 379,955 | 9.79 | 4,334.0 | 36,596 | 8.44 |
| Total asbestos | 97,815½ | 106,519.9 | 2,959,677 | 27.79 | 21,685.8 | 1,021,066 | 47.08 |
| Asbestic | ..... | 24,740.0 | 19,707 | 0.80 | ..... | ..... | ..... |

In the absence of a uniform classification of asbestos of different grades the above subdivisions have been adopted purely on a valuation basis; crude No. 1 comprising material valued at $200 and upward, and crude No. 2 under $200; mill stock No. 1 includes stock valued at from $30 to $100; No. 2 from $15 to $30; No. 3 under $15.

Output, sales and stocks in 1911 were as follows:

| | Output. | Sales. | | | Stock on Hand Dec. 31. | | |
|---|---|---|---|---|---|---|---|
| | Tons. | Tons. | Value. | Per Ton. | Tons. | Value. | Per Ton. |
| | | | $ | $ | | $ | $ |
| Crude No. 1 | 1,467.9 | 1,301.4 | 342,855 | 263.45 | 1,256.0 | 327,508 | 260.75 |
| Crude No. 2 | 3,594.5 | 3,562.7 | 402,107 | 112.87 | 3,222.7 | 404,198 | 125.42 |
| Mill stock No. 1 | 20,379.0 | 18,315.0 | 916,678 | 50.05 | 8,471.0 | 380,570 | 44.93 |
| Mill stock No. 2 | 39,289.0 | 47,826.0 | 991,370 | 20.73 | 17,794.0 | 365,458 | 20.54 |
| Mill stock No. 3 | 31,572.0 | 30,388.0 | 269,052 | 8.85 | 3,823.0 | 31,367 | 8.20 |
| Total asbestos | 96,302.4 | 101,393.1 | 2,922,062 | 28.82 | 34,566.7 | 1,509,101 | 43.66 |
| Asbestic | ..... | 26,021.0 | 21,046 | 0.81 | ..... | ..... | ..... |

Exports of asbestos during the twelve months ending December 31, 1912, are reported as 88,008 tons, valued at $2,349,353 as against 75,120 tons, valued at $2,067,259 exported in 1911.

*Quebec.*—The statistics available for the Province for 1912 given the production of asbestos as 111,175 tons valued $3,059,084 and of asbestic 25,471 tons valued $23,358. In 1911 asbestos 102,224 tons valued $3,026,306 and asbestic 25,733 tons valued $19,802.

Asbestos, as in the past years, heads the list of the products of the Quebec mines in 1912. After having passed through a severe crisis, the asbestos market is steadily improving. This is specially true for the higher grades, crude and long fiber mill-stock. The demand for the short mill-stock is not brisk, and as a consequence, the qualities under $30 a ton have to be sacrificed to some extent.

Therefore, under these circumstances, of good prices for high-grade stock and low prices for short mill-stock, it is quite easy to understand that only the mines which can produce the better qualities are able to operate satisfactorily. Hence, none of the mines of the Broughton district were operated during 1912, as the Broughton rock is essentially a milling rock, containing as a rule a good percentage of disseminated fiber, but short and low in value. The same remark applies to most of the mines of the Robertson district.

On the other hand, the Thetford mines and the Black Lake mines worked steadily and the shipments are higher than for 1911.

Figures of comparisons between the last three years are given below:

| | 1912. | 1911. | 1910. |
|---|---|---|---|
| Tons | 111,175 | 102,224 | 80,605 |
| Value | $3,059,084 | $3,026,306 | $2,667,829 |
| Average value per ton | $27.52 | $29.60 | $33.10 |

STOCK ON HAND ON DEC. 31.

| | 1912. | 1911. | 1910. |
|---|---|---|---|
| Tons | 24,176 | 33,751 | 41,159 |
| Value | $1,102,206 | $1,583,076 | $1,921,923 |

Returns of shipments in 1912 were received from nine operators, whereas in 1911, shipments had been effected by ten operators. If we compare the figures for 1912 with those of 1911, we see that the shipments increased 8.75 per cent., while the total shows an increase of only 1.07 per cent.

whole rock mined does not go to the mills, about 25 per cent. is
l too poor and goes to the waste dump; only general average
therefore be calculated. Crude asbestos is that of long fiber
the rock mined. The mill stock is the product of mechanical

treatment. For the purpose of classification in Quebec the products are based on values as follows:

Crude No. 1, $200 and over per ton; crude No. 2, $200 and under per ton; mill stock No. 1, $45 and over per ton; mill stock No. 2, $45 to $20 per ton; mill stock No. 3, less than $20 per ton.

*India.*—A deposit of amphibole asbestos with long fibers, some 8 in., is reported by the Survey in Idar State. The fiber on washing is white and of excellent quality.

*Italy.*—Italy was 40 years ago the only commercial producer of asbestos. To-day the production of Italian asbestos is small; the quality is superior in some respects to foreign asbestos but the imports are increasing. This is shown by the following table:

| | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|
| Germany tons | 5 | 6 | ..... | ..... |
| Russia tons | ..... | ..... | 250 | 212 |
| Canada tons | 2569 | 1995 | 2569 | 2990 |
| Total tons | 2285 | 2051 | 3892 | 4226 |
| Value lires | 1,599,780 | 1,435,560 | 2,335,140 | 2,535,540 |

The exports of asbestos were 571 tons valued at 318,885 lire in 1912.

*Rhodesia.*—The total production of Rhodesia including 1912 has been 1119.5 tons valued at £12,992.

The value of the asbestos exported from Southern Rhodesia, in 1911 was $13,469.

*Russia.*—The production of asbestos[1] is mostly developed in the serpentine areas of the eastern slopes of the Urals. One of these areas, 60 miles northwest of Ekaterinburg, is 6 miles long and 1400 yd. wide. The analysis of the olivine rocks of the Urals is as follows: $SiO_2$, 36.30 per cent.; MgO, 34,84; $Al_2O_3$, 1.12; $Fe_2O_3$, 5.28; $Cr_2O_3$ (+$Fe_2O_3$), 7.95; $H_2O$, 15.25. The chemical composition of the asbestos is as follows: $SiO_2$, 41.40 per cent.; MgO, 41.06; $Fe_2O_3$, 2.03; $Al_3O_3$, 1.11; $H_2O$, 14.37; total 99.97. Individual veins may vary in length from 70 to 100 ft. The work is carried on in open cuts not more than 70 ft. deep. The yield of asbestos is from 0.6 to 1.2 lb. per cubic foot of serpentine rock. The asbestos is simply broken and cobbed. The most important mines are the Voznesensky and the Zoe-Anonsky, belonging to Baron Girard de Sukanton. All this material is shipped through Reval, and these mines produce one-third of the total Russian producton. The next important mines are the Shchugi, near Mostovsky, belonging to A. Ph. Poklieffsky-Kozel Successors. Here all the material is manufactured

[1] Abstract from *Min. Journ.*, Aug. 3, 1912, p. 783.

locally into sheeting, bands, twine, thread, etc. Another mine, the Govorikhinsky, belonging to P. O. Korievo Successors, yielded 3183 tons in 1912. Other mines are the Alapievsky and the Kirtanovsky, and the mines of the Russo-Italian Asbestos Company, the N. V. Mikhanoff Company's mines, and the Uralite Company. The asbestos output of this district in recent years, has been as follows: 1906, 8001 tons; 1907, 8743 tons; 1908, 10,694 tons; 1909, 13,129 tons; 1910, 10,936 tons; and 1911, 15,872 tons.

North of the above district in the Bogosloff mining area, asbestos veins 2 ft. in thickness are worked in the Kortiakovsky mines. Other localities are on the river Uktussa, and at the Neviansky works.

Many deposits exist in the Southern Urals, as near the Miask works and in the Gavriloff copper mines.

The very best asbestos comes from Asbestovoy Hill, on the River Sissert, and also from Shelkovoy Hill on the land of the Nizhny-Tagil works.

In the government of Orenburg, the Natalievsky (Upper Ural district), the Issergansky (Orsk), and the Holmisty (Troitzk) are important mines. The Isolyator Asbestos Works Company operates in this district. The asbestos fiber longer than 3/8 in. is dried in an oven at 100 to 110° C. for two or three days. The fibers then are easily separated, those from 1 to 1/4 in. in length being used for spinning; those from 5/8 to 3/8 in. for boards, and the shorter fiber for asbestos flour for making fireproof paint.

Caucasus.—Asbestos is known to exist in a number of localities, but transportation is poor and the veins are narrow. The quality of the fiber is brittle and it occurs in talcous schists.

Siberia.—In the Angar district of Irkutsk, the "Siberian Company for the Exploitation of Asbestos," works the mines. In the Yenissei government on the Kamuisht river, asbestos occurs with dolomite veins. The yield of asbestos from the rock is about 2½ to 4½ lb. per cubic foot of rock. Other asbestos mines are worked in the Tomsk government. The absestos in the Transbaikal territory occurs in the serpentine of the Klinchinsky mine.

The asbestos deposits of Siberia and the Caucasus are uninvestigated and do not play an important part in the Russian industry. The asbestos from Ekaterinburg is of chrysolite variety, and has a high melting-point. These serpentine types of asbestos often contain only 0.29 CaO and no alumina.

According to the Torgówo Promyschlennaja Gaséta, the asbestos he Ural is in general more brittle than that from Canada. It r, used together with the Canadian asbestos, and woven in

with the longer fibers. The Ural short fiber asbestos is especially suitable for roof shingles, which in Russia have replaced the slate shingles to a large extent. The absestos exported from Russia over European Caucasus, and Black Sea frontiers, was invoiced at $805,460 in 1910, and $775,590 in 1911. The asbestos exported and declared in American consulates from Russia and Western Siberia was valued at $20,335 in 1910, $8960 in 1911, and $8110 in 1912.

According to Viestnik Finanssoff the production of asbestos in the Urals in 1911 showed an increase of 9,761,945 lb. over 1910. The total production was 34,236,518 lb., which includes the production from the following mines; Baron Girard de Sukanton, 11,584,236 lb.; Poklieffsky-Kosiel, 11,104,974; P. O. Korieff's Successors, 7,124,407; Russo-Italian Co., 2,396,318; and N. V. Muchanoff & Co., 1,966,584 lb. The Poklieffsky-Kosiel company showed the greatest increase, the Korieff company a slight decrease. Productions of recent years have been; 1907, 19,607,462 lb.; 1908, 23,935,673; 1909, 29,390,237; 1910, 24,474,573; 1911, 34.236,518 lb.

It is said that an asbestos syndicate will be formed and include the following firms, the intention being to treat asbestos rock in Russia, and to manufacture finished articles instead of exporting the raw product: Kosel successors, Girard do Sucanton, Wosnessensker Asbestos Mines, Korowo Asbestos Mines, Russo Italian Company for Asbestos Industry, Jakowlew successors. These six producers have the following, capacities, in order, 300,000 poods, 200,000 poods, 172,000 poods, 150,000 poods, 100,000 poods, 100,000 poods, total 1,022,000 poods. The only outsider of importance is the Count Stenbok-Formor Co.

*South Australia.*—An asbestos field extending over a large area is awaiting development near Robertstown. A number or prospectors were in the field and one company was formed, the Asbestos Mining Company.

*West Australia.*—The shipments of asbestos from Soanesville, Pilbara Goldfield, West Australia, were 40 tons in 1908 and 283 tons in 1909 valued at £154, but none reported since then. The serpentine area is more than 2 1/2 miles long and half a mile wide. The Nullagine series of sediments was intruded by the basic rocks altered to serpentine and this in turn by later basic dolerite dikes. The veins prospected are close to these latter. The fiber in one case was long, but most of the material requires milling. The veins are narrow, but prospecting is necessary to prove the existence of quarrying propositions.

The Asbestos Mine, 9 miles from Hawker, has two miles under search license. The workings comprise a shaft 53 ft. and a number of open cuts. The country as exposed in the shaft is decomposed clay slates and

s with many asbestos seams. Seams are also visible in streams
sbestos-bearing area is of substantial extent and worth working
natic manner. The blue asbestos promises to be available in
the mineral is crocidolite of good quality, worth cleaned from
5 per ton.

Ruedeger's asbestos show consists of 545 acres 23 miles north-
udunda. Many blue seams varying from 1 to 3 in. thick are
a prominent outcrops, and also in the wide asbestos-bearing
. The formation trends north and south. The country on the
of a pit in asbestos-bearing rock is hard limestone but seams
s show also in this rock. Twelve years ago 16 tons of asbestos
ped. Some of the veins have fibers 2 in. long.

*Countries.*—An approximate idea of the production of the world
years is as follows:

| | |
|---|---|
| Canada (1911) | 97,000 metric tons. |
| Russia (1911) | 15,500 metric tons. |
| United States (1911) | 6,800 metric tons. |
| Cape Colony (1909) | 1,500 metric tons. |
| Cyprus (1909) | 150 metric tons. |
| Rhodesia (1910) | 300 metric tons. |
| Italy (1911) | 170 metric tons. |

possible commercial producers are Portuguese South Africa and
from which shipments have been made in previous years.

## Uses of Asbestos

eculiar properties of asbestos have not been successfully imitated
tificial product. A number of products, however, include asbes-
ir make-up, so as to give the resulting manufactured product
he properties of asbestos. Asbestos may be classified into the
e and chrysotile varieties, the latter having fineness of fiber,
rength, elasticity and flexibility; the two varieties appearing to
ut the same heat-resisting qualities. The chrysotile variety
es in composition that of serpentine rock with which it is
associated. The flexibility appears to be due to the fineness
nd the smoothness of the outer surface of the separated fibers.
of asbestos may be enumerated as follows: for insulating material
g steam pipes to prevent heat losses for fire fighting apparatus
helmets, etc., theater curtains, fire-proof brick, wall plaster,
gles, roofing-felt and fire-proof paints.

lectrical insulations the uses together with other insulating
such as asphalt and gums, prevent brittleness. Asbestos wood
er for switch bases, etc., made waterproof generally with asphalt
ompounds, are found satisfactory for this and other electric ap-

paratus. A greater temperature rise in motors is allowable with certain kinds of insulation involving asbestos. The electrical properties of asbestos are not as important where it is used for electrical purposes as its heat resisting quality. It is also well known that mechanically it is not as strong as other resisting materials which lack, however, the heat-resisting quality.

In the following table of resistivity to heat., $r$ was determined as the result of numerous experiments made by C. P. Randolph[1] at the Research Laboratory, Great Barrington, Mass.

The temperature given is that on the one side of the material tested, the opposite side being at 10° C. The resistivity represents the degrees per watt per cubic inch, the watt being the electrical unit, and used to measure flow of heat.

THERMAL RESISTIVITY OF INSULATIONS CONTAINING ASBESTOS.

| Material. | Pounds per Cubic Foot. | Temperature. | r. |
|---|---|---|---|
| Diatomaceous earth and asbestos | 20.7 | 400 to 0 | 550 |
| 85 per cent. magnesia | 13.5 | 400 to 0 | 600 |
| 85 per cent. magnesia | 29.8 | 0 to 400 | 480 |
| Air-cell asbestos | 15.6 | 0 to 200 | 400 |
| Asbestos fire-felt | 7.18 | 200 | 740 |
| | 7.18 | 300 | 620 |
| | 7.18 | 400 | 430 |
| Navy brand asbestos fire-felt | 19.8 | 500 | 465 |
| | ..... | 300 | 523 |
| | ..... | 100 | 793 |
| Asbestos roll-fire-felt | 35.8 | 0 to 600 | 490 |
| "C" fiber | 22.9 | 100 | 518 |
| | 22.9 | 200 | 448 |
| | 22.9 | 300 | 395 |
| | 22.9 | 400 | 374 |
| | 22.9 | 500 | 358 |
| Asbestos fiber | 12.5 to 18.7 | 500 | 450 to 550 |
| Asbestos sponge felt | 34.4 | 100 | 1020 |
| | ..... | 200 | 830 |

Referring to the table the diatomaceous earth and asbestos is the "nonpareil high-pressure covering" made by the Armstrong Cork Company, Pittsburgh, and is a mixture of kieselguhr (pure silica) and asbestos, held together with a binder. The measurement given is the average of values found at five temperatures from 100 to 500° ,none of which vary from the mean by more than 8 per cent. and which show neither a definite increase nor decrease with the temperature. The material withstands heating to 500° C. with only a slight tendency to crumble, and may safely be used at the above temperature. It is self-supporting. The material listed as 85 per cent. magnesia is made from magnesium carbonate and asbestos fiber by the Johns-Manville Company, Boston. It cannot be used safely where it will be exposed continuously

[1] *Gen. Elec. Rev.*, Feb., 1913.

to temperatures above 300° C., as it disintegrates and carbon dioxide is evolved. If it is then subject to moisture, it will hydrate. It possesses no distinct temperature coefficient, and the value of $r$ given is the average of five measurements at temperatures from 100 to 500°. The deviation from the mean is not more than 8 per cent. The material is self-supporting. The material listed as 35 per cent. magnesia was made by the Keasbey-Mattison Company, Ambler, Pa., and contains 35 per cent. magnesium carbonate with 60 per cent. fiber. It can safely be used continuously at temperatures not in excess of 300°. It is self supporting and is called "magnasnestos."

The air-cell asbestos (Johns-Manville) is also known as "asbestocel corrugated fire-proof paper." It is self-supporting corrugated paper about 1/32 in. thick, held in shape by a paper backing. The value given for the resistivity is accurate no closer than 10 per cent., as it varies greatly with different samples. This material cannot be used at temperatures exceeding 200°, as it apparently contains an organic binder. The asbestos fire-felt (Johns-Manville) is the lightest self-supporting material we have ever been able to secure. The manufacturer states that it is made of pure asbestos fiber loosely felted together. It has a tough outer shell and is essentially a molded material. It can be used continuously at temperatures not in excess of 300° C. The navy brand asbestos fire-felt is the same material as the above, except that the density is much greater; and, according to the manufacturer, it is constructed of specially selected long-fiber asbestos. It withstands temperatures of 500° C. perfectly, while heating at 500° for eight days does not affect appreciably the resistivity—increasing it slightly, in fact. The asbestos roll fire-felt (Johns-Manville) is an asbestos cloth, flexible and very tough. It is made of pure long staple asbestos, can be used at temperatures up to 600° C. and has no distinct temperature coefficient. The "C" fiber listed (Johns-Manville) consists of asbestos fiber with a small amount of some powdered material. It can be used at 500° C., but is not self-supporting. The asbestos fiber figures relate to five samples from the Eimer-Amend Company, New York. They apparently do not change on heating to 500° C. The asbestos sponge felt (Johns-Manville) consists of layers of asbestos paper each about 0.04 in. thick. The manufacturer states that it is made of asbestos fiber and finely ground sponge. It cannot be used at temperatures exceeding 200° C., as it loses all strength above this. It is a self-supporting material.

According to the Book of Standards of the National Tube Company, the following insulating properties and data is regard to the insulation of

s is quoted:

| | Size of Pipe, Inches. | Thickness of Covering, Inches. | Loss in B.t.u. per Sq. Ft. per Hour per Degree Difference of Temperature. | Percentage of Heat Lost, Bare Pipe Loss at 100 | Authority. |
|---|---|---|---|---|---|
| Asbestos air-cell[1] | 2 | 1.26 | 0.486 | 18.0 | Stott. |
| Asbestos air-cell[2] | 4 | 1.12 | 0.525 | 19.4 | Norton. |
| Asbestos air-cell[2] | 2 | 0.96 | 0.716 | 26.5 | Jacobus. |
| Asbestos air-cell[2] | 2 | 1.02 | 0.793 | 29.4 | Barrus. |
| Asbestos fire-felt | 8 | 1.30 | 0.502 | 18.6 | Brill. |
| Asbestos fire-felt | 2 | 1.00 | 0.721 | 26.7 | Paulding. |
| Asbestos fire-felt | 2 | 0.99 | 0.766 | 28.4 | Jacobus. |

The use of asbestos for railroad ties is being exploited by a German manufacturer, Rud. Wolle. A description is given by Mr. Bloss.[3] The patented tile composed of asbestos and cement and known as Eternit[4] is used for roofs, walls and floors. Eternit is described as an asbestos cement roofing tile. The plates are produced by a mixture of asbestos and cement, and after high pressure are solid and elastic as well as frost and fire proof; some official tests have shown them superior to natural slate. These tiles are smooth and weather tight, light in weight, and come in light gray, dark gray, and red. A somewhat similar material is called "eternit wood." This comes highly finished to imitate wood veneers and is used for wainscoting and similar purposes.

An asbestos-coated steel or corrugated iron, is manufactured by the Asbestos Protected Metal Co., of Beaver Falls, Penn. The sheets of metal thus prepared are especially suitable for roofing. A specially long-fibered asbestos is applied to the surface of the metal by means of a special process in which asphalt is used, which has a very high melting-point. The metal is, therefore, encased so as to be acid-proof. The asphalt is protected by the asbestos so as to prevent its disintegration. The company manufactures asbestos-steel, a product intended for carrying a coating of concrete or cement plaster and having rectangular corrugations. This material is also used for reinforcing.

Other products as quoted, on the market early in 1913, are as follows: Asbestos building felt and sheathing in less than ton lots is 3 1/2 cents per pound for the light, weighing from 6 to 30 lb. per 100 sq. ft.; 4 cents per pound is charged for the heavy, weighing from 45 to 56 lb. per square foot.

Millboard is made in standard sheets, 40×40 in., and 41×40 in. It varies in thickness from 1/32 to 1/2 in., and in weight from 2 to 27 lb. per sheet. The net price in 100-lb. lots is 5 cents per pound.

Transite, asbestos wood, used for fireproofing, ventilators and smoke

[1] Laminated sectional with 1/8-in. asbestos paper next to pipe.
[2] Thin sheets of corrugated asbestos paper, stuck together with silicate of soda.
[3] *Elek. Kraft u. Bahnen*, Feb. 14, 1912.
[4] *Glaser's Annalen*, Nov. 1, 1912.

jackets comes in standard sheets, 36×48 in., 42×48 in. and 42×96 in. The prices, f.o.b. factory, Nashua, N. H., are for 1/8 in. thickness, weight 1 lb. $0.08; for 1-in. thickness, weight 8 lb. $0.52; for 2-in. thickness, weight 16 lb. $0.80.

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# ASPHALT

Asphalt is one of the solid native bitumens, which are composed of hydrocarbons. It melts readily with heat and is soluble in turpentine, chloroform, carbon disulphide and similar solvents and in heavy petroleum oils. Residual pitches prepared from asphaltic or semi-asphaltic petroleums by industrial processes are also termed asphalts. Owing to the different kinds of petroleum in which they originate, they are of a very varied character, and not uniform.

The supply of native asphalt comes chiefly from Trinidad and Venezuela, and the industry has increased each year. The production in the United States is given in the following table:

PRODUCTION OF ASPHALTUM AND BITUMINOUS ROCK IN THE UNITED STATES. (a)
(Tons of 2000 lb.)

| States. | 1910. | | | 1911. | | | 1912. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Tons. | Value. | Per Ton. | Tons. | Value. | Per Ton. | Tons. | Value. | Per Ton. |
| *Bituminous Rock.* | | | | | | | | | |
| California | 37,547 | $128,212 | $3.45 | 27,507 | $89,264 | $3.25 | 35,637 | $88,621 | $2.50 |
| Kentucky | 9,938 | 53,703 | 5.40 | 13,831 | 54,980 | 3.70 | ..... | ..... | ..... |
| Oklahoma (c) | 11,959 | 65,244 | 5.46 | ..... | ..... | ..... | 10,969 | 44,428 | 4.05 |
| Texas | ..... | ..... | ..... | ..... | ..... | ..... | 6,435 | 19,626 | 3.05 |
| Utah | 5,110 | 153,398 | 30.00 | ..... | ..... | ..... | ..... | ..... | ..... |
| Total | 64,554 | $400,557 | (g) $6.20 | 41,338 | $144,244 | $3.50 | 53,041 | $152,675 | $2.87 |
| *Asphaltum (b)* | | | | | | | | | |
| California | 105,463 | 1,204,854 | 11.42 | 177,690 | 2,202,490 | 12.40 | 213,694 | 2,097,782 | 9.85 |
| Oklahoma (c) | ..... | ..... | ..... | 53,566 | 325,976 | 6.09 | 54,748 | 296 945 | 5.40 |
| Utah | 755 | 43,035 | 57.00 | ..... | ..... | ..... | ..... | ..... | ..... |
| Texas | 57,713 | 1,040,825 | 18.07 | 55,826 | 786,785 | 14.05 | 88,097 | 1,384,640 | 15.75 |
| Total Asphaltum | 163,931 | $2,288,714 | g) $12.47 | 287,082 | $3,315,251 | $11.55 | 356,539 | $3,779,367 | |
| *Gilsonite (d)* | | | | | | | | | |
| Utah | 29,832 | 372,900 | 12.47 | 30,846 | 516,614 | 16.70 | 39,930 | 688,689 | 17.25 |
| Oklahoma (c) | ..... | ..... | ..... | 5,000 | 15,000 | 3.00 | ..... | ..... | ..... |
| *Mastic* | | | | | | | | | |
| California | 476 | 5,670 | 11.90 | ..... | ..... | ..... | ..... | ..... | ..... |
| Kentucky | 1,287 | 12,226 | 9.50 | ..... | ..... | ..... | ..... | ..... | ..... |

(a) From the Mineral Resources of the United States. (b) Includes hard and refined, or gum, liquid or maltha, and oil residues. (c) Indian Territory included before amalgamation into one State (d) Includes gilsonite, elaterite, grahamite, ozokerite, and "tabbyite." (g) Average value per ton.

The net imports of asphalt and bitumens into the U. S. were: 1910, 166,375 long tons; 1911, 174,234 tons; 1912, 194,775 tons, valued respectively $4.65, $4.47 and $4.72 per long ton. These quantities include in 1912 172,000 tons crude, 18,500 tons dried and 3500 tons of asphaltic limestone.

*Gilsonite.*—During the first part of 1912 the demand for gilsonite was less than usual. The gilsonite shipped over the Unitah Railway Company's road in Utah was as follows:

| | |
|---|---|
| 1909 | 27,217 tons |
| 1910 | 34,321 tons |
| 1911 | 34,511 tons |
| 1912 | 31,477 tons |

With improved transportation and the proper asphaltic oil for fluxing, this material can now be utilized for pavements. The uses have largely been for varnishes, etc.

*Other Natural Bituminous Products.*—The use of bituminous sandstone, while promising for local pavements, is likely to be superseded by asphalt, because the products are not uniform. The occurrences in Oklahoma have been described.[1] The asphalt production of Oklahoma in 1912 is stated as about 20,000 tons valued $50,000.

While a considerable tonnage of bituminous rock is reported from California, the output is declining. Both the hard asphalt and natural maltha formerly used in a mixture for pavement appear to be exhausted. In the DeBeque oil field of Colorado, beds of carbonaceous shale have been mistaken for asphalt; they yield by distillation a residue containing paraffine. Bituminous rock is also produced in Kentucky.

Rock asphalt deposits at Sunnyside, Utah, are cheaply mined and the product has been successfully used in pavements in Salt Lake City. The tonnage available is very large and the rock contains 10 per cent. bitumen. According to the United States Census $301,700 was expended on 19 asphalt mines in the United States in 1909.

WORLD'S PRODUCTION OF ASPHALT AND BITUMINOUS ROCK. (*a*)
(In metric tons.)

| | Asphalt. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year. | France. | Germany. | Hungary. | Italy. (*c*) | Spain. | Trinidad. (*b*) | United States. | Total. |
| 1902... | 21,000 | 88,374 | 2,773 | 33,684 | 6,034 | 167,253 | 36,923 | 356,041 |
| 1903... | 21,500 | 87,454 | 2,422 | 35,757 | 4,675 | 196,883 | 54,521 | 403,212 |
| 1904... | 22,000 | 91,736 | 2,221 | 34,227 | 3,463 | 137,089 | 77,250 | 367,986 |
| 1905... | 20,000 | 115,267 | 247 | 26,838 | 5,805 | 116,735 | 68,935 | 353,827 |
| 1906... | 28,231 | 138,059 | 4,111 | 34,386 | 6,229 | 132,381 | 94,316 | 437,713 |
| 1907... | 33,000 | 126,649 | 3,920 | 38,568 | 8,643 | 147,051 | 161,783 | 519,614 |
| 1908... | 41,000 | 89,009 | 4,818 | 34,761 | 9,231 | 136,583 | 134,273 | 449,675 |
| 1909... | 44,800 | 77,537 | 5,054 | 39,165 | 6,582 | 146,013 | 126,530 | 445,681 |
| 1910... | 38,500 | 81,208 | 4,994 | 41,705 | 8,473 | 161,587 | 148,760 | 485,227 |
| 1911... | 38,000 | 81,902 | 3,861 | 50,179 | 3,495 | 163,080 | 260,510 | 601,027 |

[1] MINERAL INDUSTRY, XX, p. 75.

Bituminous Rock.

| Year. | Austria. | France. | Hungary. | Italy. | Spain. | United States. | Total. |
|---|---|---|---|---|---|---|---|
| 1902..... | 897 | 258,000 | 24,873 | 64,245 | 6,301 | 35,072 | 389,388 |
| 1903..... | 1,273 | 243,000 | 21,552 | 89,690 | 6,277 | 37,334 | 399,126 |
| 1904..... | 1,435 | 277,000 | 17,660 | 111,390 | 3,761 | 19,454 | 380,700 |
| 1905..... | 4,363 | 191,509 | 19,372 | 106,586 | 5,725 | 32,337 | 359,892 |
| 1906..... | 2,840 | 196,375 | 34,664 | 130,825 | 7,794 | 21,848 | 394,348 |
| 1907..... | 3,858 | 177,000 | 33,096 | 161,126 | 8,219 | 41,301 | 424,600 |
| 1908..... | 3,695 | 171,000 | 72,972 | 134,163 | 12,373 | 33,901 | 428,104 |
| 1909..... | 2,975 | 169,000 | (*d*)70,000 | 111,067 | 5,284 | 50,243 | 408,569 |
| 1910..... | 1,066 | 170,000 | (*d*)70,000 | 162,212 | 7,795 | 58,581 | 469,654 |
| 1911..... | 1,740 | 169,697 | ..... | 188,133 | 3,741 | 37,512 | ..... |

(*a*) Statistics of production in Barbados, Cuba, Mexico, Russia, Switzerland, and Venezuela are not available. (*b*) Exports. (*c*) Including mastic and bitumen. (*d*) Estimated.

*Ozocerite.*—The virtual exhaustion of spot stocks of the crude wax during 1912 has resulted in a marking up of the nominal quotations for both brown and green, the former to 20@21 cents and the latter to 21@22 cents, the inside figures having been advanced 2 cents for the first-mentioned grade and 1 cent for the second description.

The mineral was imported to some extent during 1912. From Austria the ozocerite exported in 1910 was 2554 tons, valued at $700,000. The ozocerite and ceresin invoiced for export through Vienna were valued at $302,013 in 1910 and $167,887 in 1911. The exports of ozocerite in 1912 for Austria-Hungary were 2525 tons valued 3,660,960 K.

## Notes on Foreign Countries

*Austria-Hungary.*—The export of asphaltic rock in 1911 was 1845 tons and in 1912, 1357 tons valued 33,942 K. In 1911 the mastic and bitumen export was 1218 tons and in 1912, 1920 tons valued 183,812 K. The production of asphaltic rock in 1911 was 1740 tons valued 77,856 K; the asphalt produced in Hungary in 1911 was 3861 tons, valued 530,090 crowns. The imports far exceed the exports; Austria-Hungary imported crude rock: 18,394 tons in 1911 and 25,111 tons in 1912, the latter valued 1,215,741 K; and mastic and bitumen: 1990 tons in 1911 and 4295 tons in 1912 valued at 598,618 K.

*Colombia.*—The asphalt exported as declared at Barranquilla, Colombia, to the United States, was worth $1100 in 1910, and $2140 in 1911.

*Cuba.*—The invoiced declarations of exports from Cuba, are valued at the following: 1911, $44,643, and 1912, $86,031. Of this from Havana, $37,604 was exported in 1911, and $71,564 in 1912; from Cienfuegos in 1912, $1807, and from Caibarien $7039 and $12,660, in 1911 and 1912 repectively. The amount of crude imported from Cuba into the U. S. in 1912 was 17,228 tons.

*Germany.*—The condition of the asphalt industry was the same in 1910, 1911 and 1912. The importation of asphalt being duty-free has caused competition. It is understood that after testing Texas asphalt, asphalt oil and petroleum asphalt, the Government has classified them to be duty-free.

According to Consul General Robert P. Skinner, there appears to be a fairly steady demand in Hamburg for hard American asphalt but not for other grades. It must be of fine luster for varnish making and should be packed in bags. Prices offered per 220 lb. f.o.b. Hamburg range from $1.90 to $5.95.

Germany's imports of asphalt from the United States amounted to 3753.7 metric tons in 1909 and 3817.2 tons in 1910. In 1911 and 1912 the Empire's total imports of asphalt and the countries of origin were as follows:

| | 1911. | 1912. |
|---|---|---|
| | Tons. | Tons. |
| Total importations | 133,634.5 | 147,783.7 |
| Whereof from— | | |
| Italy | 87,544.5 | 95,132.4 |
| Switzerland | 11,532.0 | 18,273.9 |
| Newfoundland | 21,782.9 | 22,266.4 |
| United States | 4,261.7 | 4,927.1 |
| Value of total importations | $1,431,332 | $1,582,700 |

The Imperial Ministry has compiled data from the various manufacturers in the asphalt industry in Germany, as follows:

| Asphalt. | 1909. | 1910. | 1911. |
|---|---|---|---|
| Number of pits | 15 | 15 | 14 |
| Number of employees | 198 | 186 | 183 |
| Production of rock asphalt, metric tons | 76,964 | 81,335 | 84,607 |
| Pure asphalt contained in this rock: | | | |
| Metric tons | 4,399 | 4,641 | 4,771 |
| Value | $152,857 | $163,737 | $152,290 |

The Lobsann Asphalt Company of Amsterdam now work the Lobsann deposits (Alsace-Lorraine); these deposits were the source of the first asphalt used in paving French streets, 60 years ago. The deposit occurs at depth and is 7 to 14 ft. thick. The crushed rock is shipped in the form of powder for roadways, or in compressed paving slabs or in the form of mastic cakes (50 lb. each). The mastic contains 20 per cent. bitumen.

The value of the asphalt exported to the United States from Brunswick, Germany, was $18,499 in 1910, and $22,532 in 1911.

*Italy.*—The bituminous rock produced from establishments in 1910, in Italy, was 162,212 tons, valued at 2,256,920 lires. In 1911 fifteen establishments produced 188,133 tons, valued at 2,955,427 lires. The asphalt, mastic, and bitumen, produced in Italy from five or six works, was as follows: 1910: 41,705 tons, valued at 1,128,823 lires; 1911: 50,179 tons, 1912: 52,747 tons, valued at 1,566,524 lires; The natural bitumen produced was:

1910: 457 tons, valued at 69,750 lires; 1911: 548 tons, valued at 109,600 lires.

*Spain.*—The number of mines producing asphalt in Spain in 1912, was 7. The area of these mines was 160 hectares, and 41 men were employed. The production was 3741 tons, valued at 44,980 pesetas at the mine.

*Trinidad.*—The amount of Trinidad liquid asphalt used for surfaces of roads was 4653 tons in 1911 and 18,902 tons in 1912. This material which is free from paraffine comes from wells of the General Asphalt Company and is used directly or after distillation of the lighter elements.

The output of asphalt from Trinidad is estimated at 250,000 tons in 1912. The total exports of asphalt were 179,718 short tons in 1911 and 189,496 tons in 1912. About one-half was shipped to the U. S. in 1912.

*Venezuela.*—The sales of Bermudez road asphalt during recent years were: 1909, 1500 tons; 1910, 6918 tons; 1911, 20,479 tons; 1912, 31,289 tons. Asphalt deposits are found near the Lake of Maracaibo and also in the eastern part of the country near the San Juan River, a short distance from the port of Caño Colorado. This last deposit is exploited by an American corporation and the product is shipped to the United States. A concession has been granted to another American corporation to make explorations for petroleum and asphalt over a large part of Venezuela. Engineers and geologists for this corporation are now in the field.

The exports from Venezuela, in asphalt during the year 1911, as reported by the Ministry of Finance, were valued at $250,219. The asphalt exported to the United States during the year 1910 was $13,931. Exports from Caño Colorado, to the United States in 1911 were valued $243,891 and from Cumana to the United States $18,153.

*Other Countries.*—Samples of bitumen reported from the Falkland Islands a few years ago[1] and from Gold Coast, Africa,[2] are chiefly of interest as showing the possible occurrence of petroleum below these indications. The African specimen mentioned is similar to the deposits

[1] *Bull. Imp. Inst.*, 1912, p. 400.
[2] *Bull. Imp. Inst.*, 1912, p. 583.

of bituminous sandstone near Lagos, investigated before by the Mineral Survey of Southern Nigeria.

*Properties of Native Asphalts.*—A classification of bitumens is given by Herbert Abraham.[1] Another classification is worked out by Dr. Day,[2] the German Society for testing materials and Prof. Marcusson. An elaborate classification also gives physical and chemical characteristics of bitumens.[3] The difference between grahamite and asphalt and gilsonite was defined by Clifford Richardson.[4] The properties making certain asphalts and bitumens suitable for electrical work are enumerated in an article by C. Toone.[5] The difference between the properties of Venezuelan and Trinidad asphalts are as follows:[6]

The properties of native asphalts are modified when they are combined with a *flux* to produce an asphalt cement. Cement made from Trinidad and Bermudez asphalt are characterized by a definite specific gravity in each case, a certain ductility, as determined by a conventional test, by containing little volatile matter, by the fact that it has a certain viscosity with which other asphalt cements can be compared, and contains a considerable amount of sulphur, which has an important bearing on its stability. These cements, in addition, possess adhesive binding and cementing properties and are not short, cheesy and oily. They do not harden excessively when exposed to low temperatures or become too liquid under the summer sun. They do not contain a large portion of light oils volatile during the period in which the material is maintained in a melted condition or on mixing with a hot mineral aggregate. They have great viscosity at atmospheric temperatures but become sufficiently mobile at higher temperatures to mix satisfactorily with the mineral aggregate.

The successful use of Trinidad asphalt may be attributed to its uniformity. Every cargo of this asphalt during the last 36 years, has been found to be practically like another.

The proportions are as follows:

| | |
|---|---|
| Bitumen | 39.3 per cent. |
| Mineral matter | 27.2 per cent. |
| Water of hydration of clay | 3.3 per cent. |
| Water and gas, loss at 325° F. | 29.0 per cent. |
| | 98.8 per cent. |

The lake has a surface of more than 1000 ft. in diameter and a depth of over 135 ft. Trinidad asphalt is subjected to so-called refining which amounts really to drying the material and removing the water entering into the emulsion which composes the crude material. Some of the

[1] *Eighth Intl. Congr. Appl. Chemistry*, 1912; *Journ. Ind. and Eng. Chem.*, Jan., 1913.
[2] *Eng. and Min. Journ.*, July 27, 1912.
[3] *Eng. and Min. Journ.*, Dec. 30, 1911.
[4] *Journ. Am. Chem. Soc.*, Sept., 1910, pp. 1032–1049.
[5] *Cassier's Magazine*, Jan., 1911.
[6] Clifford Richardson, "Asphalt Construction," 1913.

characteristics of the refined material are as follows: Specific gravity at 77° F., 1.397; melting-point, 230° F.; color of powder or streak, blue-black; luster, dull; loss at 325° F. for five hours, 0.8 per cent.; character after heating, smooth; composition: bitumen soluble in $CS_2$, 55.8 per cent.; mineral matter, 36.3; difference, 7.9; bitumen soluble in 88° naphtha, 38.0 per cent. (per cent. of total bitumen 66.2); bitumen yields on ignition: residual coke, ash-free, 12.7.

Bermudez asphalt found in Venezuela, differs from the Trinidad asphalt in carrying no admixture of mineral water, being a nearly pure bitumen. The deposit is not as uniform as that of Trinidad, and the material as dried or refined, varies from time to time in its consistency. It hardens on heating through loss of volatile oils more rapidly than the Trinidad material, and its manipulation requires greater care to produce a satisfactory asphalt cement. It possesses certain properties, however, which makes it preferable to Trinidad asphalt in that it melts to a thinner liquid owing to the absence of mineral matter, and on this account permits of easier manipulation. At the same time it lacks the stability of Trinidad asphalt and suffers more from abuse in melting and mixing with hot aggregates. The refined material is much softer than the refined Trinidad asphalt. It varies in degree depending on the part of the lake-deposit from which the crude asphalt is taken. Some of the characteristics of the supply marketed in 1912, are as follows: Specific gravity at 77° F., 1.075; melting-point, 183° F.; color of powder or streak, black; luster, bright; loss at 325° F. for five hours, 2.8 per cent.; character of residue, smooth; composition: bitumen soluble in $CS_2$, 92.5 per cent.; mineral matter, 4.9; difference, 2.6; bitumen soluble in 88° naphtha, 64.0 per cent. (per cent. of total bitumen 69.2); bitumen yields on ignition: residual coke, ash-free, 13.4 per cent. Bermudez asphalt has been subjected to service tests since 1893 and when combined with a suitable mineral aggregate has given entirely satisfactory results, surfaces constructed with it being of a durable nature. It has been much used in the last four or five years as a cementing material for bituminous broken-stone highways, and has proved extremely successful as applied to this form of construction, owing to the fact that it can be used in the penetration process with much greater ease than a similar binding material made from the more viscous Trinidad asphalt, although the Trinidad asphalt is equally satisfactory, as used in New York State, when once it is satisfactorily introduced into the road surface.

According to a recent article[1] the properties of asphalts and other native bitumens is compared with those of petroleum residuums (see Petroleum). The following table gives details:

[1] Clifford Richardson, *Eng. Rec.*, April 26, 1913.

| | Pene-tration. | Bit. Sol. in $CS_2$. | Per cent. Pure Bit. Sol. in 88 Deg. Naph. | Per cent. Pure Bit. as Sat. Hydro-carbons. | Sulphur. | Residual Coke, Ash-Free. |
|---|---|---|---|---|---|---|
| ..... | 7 | 56.5 | 63.1 | 24.4 | 6.2 | 10.8 |
| ..... | 0 | 54.1 | 61.9 | 21.8 | 5.0 | 12.9 |
| ..... | 22 | 95.0 | 65.4 | 24.4 | 4.0 | 13.4 |
| ..... | 26 | 96.0 | 71.9 | 23.4 | 4.7 | 14.0 |
| ..... | 20 | 96.8 | 47.2 | 25.3 | 5.7 | 18.0 |
| ..... | 0 | 75.1 | 43.1 | 17.0 | 8.3 | 25.0 |
| ..... | 0 | 49.3 | 43.8 | 8.1 | 6.2 | 14.9 |
| ..... | 0 | 99.7 | 23.6 | 6.5 | 8.5 | 15.0 |
| ..... | 0 | 99.2 | 27.3 | 6.7 | ..... | 25.0 |
| *er than as-* | | | | | | |
| ..... | 0 | 99.0 | 47.7 | 5.9 | 1.7 | 13.0 |
| ..... | 0 | 94.1 | 0.4 | 0.3 | 1.7 | 53.3 |

ts is always 4 to 8 per cent.; paraffine scale is absent; c a material is the less saturated hydrocarbons it con- property is not due to harder consistency, as Mexican if the same consistency is very much higher in saturated

*lucts from Petroleum.*—In the western states the con- quantities of asphaltic oils which predominate, is a ; solution. It is hardly a matter of competition with ılts the properties of which are not the same. The mpanies to put in asphalt stills is increasing. During l Oil Company will probably have in operation 45 stills city each for asphalt manufacture. During 1912 at ılone 15 such stills were constructed. Other companies , the Associated and the United States are also embark- y to a less extent and the disposal of heavy oil much of is assured. The proper distillation at low temperature oils in order to obtain a suitable residue was first Barber Asphalt Paving Co. It is now recognized residues, that is, those obtained in distilling for the contain substances insoluble in carbon tetra-chloride for pavement work now mention the use of this test. heavy residuums with sulphur at high temperatures a successful product for paving. The "blown" oils, d by oxidation and dehydrogenation with air, have to in the market; they are sometimes used with gilsonite. c oils from Mexico, whence they are cheaply exported are recently distilled for residuum-pitch both in the l in Mexico. The residue, however, contains paraffine purely asphaltic nature and has not been produced of

sufficiently uniform grade to allow its successful use in pavements. It is possible that these difficulties will be overcome as the industry develops. Details will be found in the article on petroleum.

Arkosite is a trade name given to a true asphaltite. Its properties make it suitable for rubber compounds, rubber hose, paints, etc. It is chemically inert, neutral, non-conducting and may be reduced to a fine powder; it is insoluble, does not melt and decomposes only at high temperatures. With linseed oil it forms a protective acid resisting coating for steel, etc. It retards the aging of linseed oil, leaving it tough and soft.[1]

## Asphalt Road Construction

An increase in the amount of sheet asphalt laid in the American cities and of the asphaltic concrete and asphaltic broken stone pavements requires that more and more highway engineers and others specialize in the details of this work. The following data are abstracted from "Asphalt Construction."[2]

In the early days of the sheet-asphalt paving industry a so-called bituminous foundation, consisting of a coarse broken stone, bound with bituminous material, was in use, but has been abandoned in good practice, as it possessed no rigidity.

It was soon found that greater stability was obtained in the surface if a binder course of stone was used between the foundation and the surface. Close binder consists of the same broken stone of which the open binder is made, but the voids in it are filled with smaller stone and with an asphaltic mortar corresponding to the ordinary asphalt surface mixture. For the construction of a close binder or asphaltic concrete of the highest type, the grading of the mineral aggregate should be carefully regulated. An excess of bitumen or an excess of fine material must be equally avoided.

The following examples show the proportions in use:

| | Plant 1, New York, Per cent. | Plant 2, New York, Per cent. | Boston, Per cent. |
|---|---|---|---|
| Coarse stone | 480 lb. = 54.6 | 480 lb. = 53.3 | ..... |
| Fine stone | 200 lb. = 22.7 | 202 lb. = 22.4 | 885 lb. = 73.4 |
| Sand | 150 lb. = 17.0 | 150 lb. = 16.7 | 250 lb. = 20.8 |
| Trinidad asphalt cement | ..... | 68 lb. = 7.6 | 70 lb. = 5.8 |
| Bermudez asphalt cement | 50 lb. = 5.7 | ..... | ..... |
| | 880 lb. = 100.0 | 900 lb. = 100.0 | 1205 lb. = 100.0 |

Aggregates containing fine stone of the type of which asphalt blocks are composed consist of an admixture to the fine material of small broken

[1] *Journ. Ind. and Eng. Chem.*, Jan. 1913.
[2] By Clifford Richardson, McGraw Hill Pub. Co., 1913.

stone or pea grit, and are also employed for monolithic sheet work. They have been constructed on a large scale within the year 1912. It is improper to call these asphaltic concrete, as the stone should constitute more than 50 per cent. of an aggregate, in order that it may be classed as a true concrete. The composition of an asphalt block would average about as follows: Density of block, 2.53 per cent.; bitumen, 7.3 per cent.; passing 200 mesh, 16.7 per cent.; passing 10 mesh, 39.5 per cent.; passing 8 mesh, 7.0 per cent.; passing 1/4-in. holes, 26.5 per cent.; retained 1/4-in. holes 3.0 per cent.

Asphaltic concrete consists for the largest part of broken stone, either of uniform or graded sizes, the voids in which are filled with a mortar, a Portland cement mortar in the case of hydraulic concrete and an asphaltic mortar in the case of asphaltic concrete. It is becoming more frequent to construct the wearing surface of a pavement with asphaltic concrete. In that case there is no intermediate course. The grading of such a mineral aggregate is a more important matter than when it is used as a binder and protected by a a sheet asphalt surface. Asphalt concrete laid on Thirteenth Street, Washington, D. C., 1910, as shown in the table, combines the ordinary sheet asphalt surface mixture with the open binder, the former filling the voids. These two mixtures while satisfactory are plainly deficient in filler.

| | Per cent. | | Per cent. | |
|---|---|---|---|---|
| Bitumen | 7.8 | | 7.5 | |
| Passing 200 mesh | 2.7 | 32.7 | 1.6 | 27.9 |
| Passing 10 mesh | 30.0 | | 26.3 | |
| Passing 8 mesh | 0.8 | 4.6 | 0.6 | 3.6 |
| Passing ¼-in. holes | 3.8 | | 3.0 | |
| Passing ½-in. holes | 14.0 | | 12.4 | |
| Passing ¾-in. holes | 22.5 | 54.9 | 17.0 | 61.0 |
| Passing 1-in. holes | 11.4 | | 17.4 | |
| Retained 1-in. holes | 7.0 | | 14.2 | |
| | 100.0 | | 100.0 | |

*Sheet asphalt surfaces* consist of a mineral aggregate of sand, at times some fine stone, filler of impalpably fine ground mineral matter and an asphalt cement. It may be looked upon as an asphalt mortar, or where broken stone is present to the extent of 50 per cent. or more, as an asphaltic concrete. In a sheet asphalt pavement of the ordinary type, sand forms at least 80 per cent. of the mineral aggregate, the remainder consisting of filler and asphalt cement.

An impalpably finely ground mineral matter or dust is used as a filler in combination with sand to complete the mineral aggregate for surface mixtures in order to render the surface when compressed more dense, and to render the asphalt cement which is one of the components more stable

and less susceptible to the high temperatures to which it may be subjected under the summer suns of our climate. It makes the surface, at the same time, less susceptible to water action, and less liable to displacement under travel. As Trinidad asphalt cement contains a large percentage of clay and impalpably fine quartz acting as a natural filler it is not necessary to add as much artificial filler as in the case of Bermudez asphalt, which is a nearly pure bitumen. In turning out a Trinidad surface mixture, therefore, but 80 lb. per 9 cu. ft. box may be necessary with Trinidad for ordinary work whereas 100 lb. or more must be used with a Bermudez asphalt cement. Regard must also be given to the fact that the density of Portland cement is much greater than limestone, and a greater weight of the former material must be used than of the latter if the same volume of filler is to be provided.

The following table shows the grading and percentage of surface mixtures. Column 1 is the mixture used for the famous Thames Embankment road in 1906; it was made of 16.5 per cent. asphalt cement; 18.4 per cent. dust; 65.1 per cent. sand. Column 2 was laid at Fulham, London, 1894, and not successful on account of scaling. Column 3 was the satisfactory mixture substituted in 1896. Column 4 gives the mixture used in New York in 1912; it is adopted to the condition of the sand supplies which are not the same as in 1896-97. Column 5 shows the 1896 mixture and column 6 the 1897 mixture used on Fifth Ave., New York City.

TABLE OF SURFACE MIXTURES.

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Bitumen | 11.5 | 10.0 | 10.8 | 10.6 | 10.8 | 10.6 |
| 200 mesh (per inch) | 17.5 | 7.4 | 13.6 | 13.4 | 15.4 | 17.4 |
| 100–200 mesh | 7.0 | 15.9 | 7.3 | 8.0 | 10.5 | 12.3 |
| 80–100 mesh | 23.0 | 11.4 | 22.5 | 8.0 | 10.7 | 11.1 |
| 50–80 mesh | 32.0 | 11.1 | 25.5 | 26.0 | 22.3 | 23.3 |
| 40–50 mesh | 6.0 | 24.0 | 8.9 | 11.0 | 10.9 | 8.8 |
| 30–40 mesh | 3.0 | 12.2 | 6.6 | 15.0 | 8.9 | 8.0 |
| 20–30 mesh | 0.0 | 5.0 | 3.0 | 5.0 | 4.9 | 4.7 |
| 10–20 mesh | 0.0 | 3.0 | 1.8 | 3.0 | 5.6 | 3.7 |

For the production of an asphalt cement of suitable consistency for use in sheet asphalt pavements or as a road binder, the refined native asphalt must be combined with heavy oil, or residues from the distillation of various petroleums, which are known as fluxes. These fluxes vary from year to year.

For many years the fluxes or residuums originated in the paraffine petroleums of the East. The fluxes which are on the market in 1913 are derived from semiasphaltic and asphaltic oils which have the characteristics given in the following table. Many of them are available only in a limited amount commercially.

FLUXES AVAILABLE IN 1912.

| Identification. | M.O. Co., Neodesha, Kan. | K. Co., N. O. Co., Brooklyn, N. Y. | M.O. Co., Baton Rouge, La. Ilely. | M.O. Co., Whiting Ind. | M.O. Co., Sugar Creek, Mo. | Indian Ref. Co. | Trinidad Flux. | Mexican Flux. | California Flux. |
|---|---|---|---|---|---|---|---|---|---|
| Sp. gr. at 60° F. | 0.944 | 0.933 | 0.934 | 0.931 | 0.957 | 0.961 | 1.007 | 1.003 | 1.024 |
| Beaume equivalent | 18.3 | 20.1 | 19.9 | 20.4 | 16.3 | 12.7 | ..... | ..... | ..... |
| Flash° F. | 455 | 410 | 505 | 430 | 505 | 495 | 350 | 375 | ..... |
| Paraffine scale | 3.6% | 4.4% | 1.4% | 3.3% | 4.2% | 3.1% | 0.3% | 1.3% | 0.6 |
| Residual coke | 3.0% | 3.5% | 2.7% | 2.0% | 5.9% | 7.7% | 7.0% | 10.0% | 9.4 |
| Sulphur | 0.6% | 0.4% | 0.6% | 0.5% | 0.7% | 0.5% | 2.6% | 4.3% | 1.17 |
| Loss seven hours 325°F., 20 grm. | 0.4% | 2.0% | 0.1% | 1.0% | 0.2% | 0.2% | 6.0% | 4.1% | 0.2 |
| Insoluble in 88° naphtha-pitch | 2.8% | 2.5% | 0.4% | 2.4% | 8.5% | 9.6% | 13.9% | 18.8% | 12.5 |

In the case of a flux of lower gravity a smaller amount is required to produce an asphalt cement of suitable consistency for paving purposes than of a heavier one. About 20 lb. of the lighter flux are required for each 100 lb. of refined Trinidad asphalt, and about 7 lb. with the present supply of Bermudez refined asphalt. A much larger amount of the heavier asphaltic flux is necessary owing to their greater density and viscosity. This may reach as much as 40 or 50 lb. per 100 of asphalt instead of 20, as in the case of the paraffine fluxes.

In the preparation of an asphalt cement the refined material and flux must be thoroughly combined. The refined asphalt must be carefully weighed, melted and raised to a temperature of at least 325° F. and not above 350° F. The flux should be heated to a temperature of 150° to 200° F. Under the most favorable circumstances three hours agitation is necessary and, with inferior agitation, a much longer time may be required.

Bituminous broken-stone surfaces are constructed by either the so-called penetration or by the mixing process. The asphaltic cement is not however, used in the same way in both, although the character of the material should be quite the same.

In the penetration process the stone is placed in the road in the manner that it would be if a water-bound broken-stone road was to be constructed, and the asphalt cement is applied to it in the amount decided upon, as uniformly as possible. This may be done after the stone is thoroughly compressed under the roller, or it may be partially compressed, the asphalt cement then applied, and final rolling completed, as may be considered most desirable.

Assuming that Bermudez asphalt cement is used, it is very important that the temperature of the asphalt cement or road binder should be carefully regulated with thermometers. It should never be heated above 375° F. for two reasons; the road binder may be injured thereby and is,

under any circumstances, hardened rapidly at high temperatures and it may be too liquid. It should not fall below 340° F. and not as low as that in extremely cold weather. The temperature must be regulated to a certain extent according to atmospheric conditions.

*Asphalt Surface or Carpet Coats.*—It has been a common practice for some time in Great Britain and on the Continent, to make an application of coal tar in its various forms to old road surfaces to prevent dust. In America it is found that asphalt oils and residuals which contained a considerable percentage of paraffine hydrocarbons do not have sufficient adhesive and binding qualities, but some oils found in California, in Mexico and in Trinidad are suitable. Whatever the material which may be used for a carpet coat, it should be applied with a mechanical distributor capable of handling it in a heated condition, preferably under pressure and either atomized or not.

*Roads.*—The pavements and roads to which materials for the General Asphalt Company were applied during 1912 were 12,873,200 sq. yd. and the macadam treated was 13,664,247 sq. yd. a total of 26,539,419 sq. yd. In 1893 the total area of Trinidad asphalt roads in existence in the United States were only 14,000,000 sq. yd. The amount of asphalt imported at that time into the United States was annually 85 to 95,000 tons, 96 per cent. being used for pavements.

The Office of Public Roads of the Dept. Agriculture published a pamphlet[1] gives information on bituminous macadam roads, their construction, maintenance, etc.

A description of conditions of many classes of roads in 1912 specially those where other bituminous materials than asphalt were used is that of S. F. Peckham on a trip through the United States in 1912.[2]

The repair of asphalt surfaces is discussed in a paper by W. L. Hempelman.[3]

Spencer J. Stewart, New York State department of Highways, gives costs, etc., for a bituminous gravel concrete pavement.[4]

An investigation of Municipal Asphalt plants, Costs of Paving, etc., was made by D. E. McComb.[5]

Specifications for tar binders and methods of distilling are given in a paper by Philip D. Sharples.[6]

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[1] Descriptive Catalogue of the Road Models of the Office of Public Roads, Washington, 1913.
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# BARYTES

By F. Julius Fohs

The barytes industry during 1912 showed marked improvement over 1911 in point of production, increased demand, and value both of crude and refined. The production continued from Missouri, North Carolina, Georgia, Kentucky, Tennessee, California and Virginia, the amount decreasing in the order named, almost two-thirds coming from Missouri, and of the Missouri product but little was produced outside of Washington County.

In 1912, the domestic production of crude barytes amounted to 46,472 short tons valued at $209,275, an increase of 20.8 per cent. in quantity and 71.2 per cent. in value over 1911. About 45,457 tons were bleached and milled having a value of $579,765, an increase of 14.7 per cent. in quantity and 15.2 per cent. in value over the previous year; a small tonnage included in this, was refined from imported crude. Of the total refined, about 85 per cent. was bleached, the remainder ground only. About 1525 tons of crude valued at $6087 was marketed aside from that supplied the refining mills. The production grouped by states was as follows: Missouri, 30,604, Georgia, Tennessee, Kentucky, 9132; North Carolina, Virginia, California, 6736 tons.

The average value of the crude barytes produced was $4,525, as against $3.19 in 1911, an increase of 41.9 per cent. in value per ton. The average value of refined was $12.75 per ton as against $12.72 per ton in 1911, showing only a very slight increase. There was practically no tonnage in stock the first of the year in the hands of the milling companies.

The value of crude during 1912 ranged from $3.50 to $7 per ton being least in Tennessee and highest in Missouri, the price in the latter state having increased from $4.50 the early portion of the year to $7 per ton in November. The value of bleached ranged from $13.25 to $17, while that of milled ranged from $10 to $13.

The production in Missouri comes chiefly from Washington County where the mineral is gophered by diggers who sell to a few buying con-

cerns; who in turn sell to the mills. The Bryant Barytes Lead Co. has undertaken to recover by means of mill concentrators[1], the barytes from lead tailing dumps in Cole County and was responsible for a small tonnage. Since the Washington County mineral is produced chiefly from the barytes residual in clay usually less than 15 ft. deep, from the breaking down of cave and vein deposits, it is heavily clay- and iron-stained for the most part. The diggers are paid $3.10 to $4 for the mineral f.o.b. railroad and since they can only work in favorable weather and having no other resource, they barely exist upon the wages earned. Royalties range from 50 cents to $1 while haulage costs 40 cents to $2.50 per ton. The extra freight rate is the chief drawback to development in other counties. Some further development, however, is contemplated in Cole County.

In North Carolina, the production was by scattered producers, at Niota, Lawton, and Hot Springs. This baryte while long, fibrous and dark colored, bleaches readily. The Georgia product is largely of good grade and produced only at Cartersville. Kentucky has but one company actively producing with a number of farmers supplying small tonnages. An attempt was made here to separate calcite from barytes at the Cole mine but for some reason the jigs were soon abandoned. Most of the present mining is from shallow pits. In Tennessee, although the mineral is abundant, heavy haulage costs and $1 additional freight rate makes competition in open market almost prohibitable. Small tonnages were shipped to Kentucky and possibly to some of the chemical product plants. A large amount of iron crust in some of the barytes has also been a drawback but large tonnage of good quality can be secured readily. Virginia and California productions were quite small. The California product is sold crude possibly to paint manufacturers on the Pacific coast who grind it themselves.

Imports of barium products in 1912 were slightly lower in value than in 1911, that year having shown a decrease likewise over 1910. The following table shows these imports in detail. There is a duty and properly so on all these products, except barium carbonate and this consequently cannot be produced from domestic barytes in competition with the foreign except on the Atlantic coast when made from low-grade imported crude barytes. The duty on refined or manufactured barytes is necessary to the maintenance of the industry. The duty on crude ($1.50 per ton) is not enough to be of material help to the Missouri producer, and yet without it the more eastern states would be practically shut out of production.

[1] *Eng. and Min. Journ.*, Feb. 8, 1913.

STATISTICS OF BARYTES IN THE UNITED STATES.

| Year. | Production. | | | Imports. | | | | Consumption. | |
|---|---|---|---|---|---|---|---|---|---|
| | Short Tons. | Value. | | Crude. | | Manufactured. | | | |
| | | Per Ton. | Total. | Sh. Tons. | Value. | Sh. Tons. | Value. | Sh. Tons. | Value. |
| 1899.... | 32,636 | $4.20 | $137,071 | 1,739 | $ 5,488 | 2,111 | $22,919 | 36,486 | $165,478 |
| 1900.... | 41,466 | 3.90 | 161,717 | 2,568 | 8,301 | 2,454 | 24,160 | 46,488 | 194,178 |
| 1901.... | 49,070 | 3.22 | 157,844 | 3,150 | 12,380 | 2,454 | 27,062 | 54,674 | 197,286 |
| 1902.... | 58,149 | 3.21 | 186,713 | 3,929 | 14,322 | 3,908 | 37,389 | 65,986 | 238,424 |
| 1903.... | (a)50,397 | 3.02 | 152,150 | 6,344 | 22,777 | 5,716 | 48,726 | 62,457 | 223,653 |
| 1904.... | (a)65,727 | 2.66 | 174,958 | 6,689 | 27,463 | 5,920 | 48,658 | 78,336 | 251,070 |
| 1905.... | 53,252 | 3.68 | 196,041 | 7,879 | 36,796 | 4,827 | 39,803 | 65,418 | 272,649 |
| 1906.... | 63,486 | 3.98 | 252,719 | 9,189 | 27,584 | 4,808 | 37,296 | 77,483 | 317,599 |
| 1907.... | 65,579 | 3.83 | 251,308 | 18,344 | 77,683 | 10,006 | 96,542 | 93,929 | 425,533 |
| 1908.... | 38,546 | 3.38 | 130,409 | 12,197 | 58,822 | 3,037 | 29,168 | 53,780 | 218,399 |
| 1909.... | 39,831 | 3.54 | 138,634 | 12,422 | 35,387 | 2,240 | 19,320 | 54,493 | 193,338 |
| 1910.... | 41,720 | 3.49 | 145,187 | 18,992 | 48,457 | 3,184 | 29,782 | 63,896 | 223,426 |
| 1911.... | 41,057 | 3.72 | 152,732 | 20,015 | 36,643 | 3,148 | 22,083 | 64,220 | 211,458 |
| 1912.... | 46,472 | 4.53 | 209,275 | 26,185 | 52,467 | 3,285 | 26,848 | 75,942 | 238,390 |

(a) Statistics of the U. S. Geological Survey.

PRINCIPAL COUNTRIES IN WHICH BARYTES IS PRODUCED.
(Metric tons.)

| | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|
| Austria-Hungary (exports) | | | | | |
| Barium chloride | 2,974 | 2,585 | 4,344 | 3,741 | 3,659 |
| Barytes | 2,987 | 3,737 | 13 | 12 | 2,690 |
| Belgium (production) | 25,070 | 31,400 | 4,960 | 25,200 | 32,400 |
| Canada (production) | 3,911 | *Nil.* | *Nil.* | 50 | ..... |
| France (production) | 16,277 | 14,111 | 11,632 | 10,064 | ..... |
| Baden (production) | 8,554 | 15,186 | 13,832 | 15,014 | 15,871 |
| Bavaria (production) | 17,195 | 17,920 | 24,711 | 26,234 | ..... |
| Germany (exports) | | | | | |
| Barytes | 91,111 | 90,555 | 114,264 | 128,452 | 142,681 |
| Barium white | 5,190 | 4,888 | 5,528 | 6,834 | 8,242 |
| Barium chloride | 3,389 | 5,340 | 6,403 | 6,180 | 8,096 |
| Barytes (imports) | 19,969 | 14,560 | 5,782 | 7,926 | 18,666 |
| Italy (production) | | | | | |
| Barytes, ground | 1,895 | 1,950 | 1,333 | 1,452 | 1,088 |
| Barytes, crude | 15,732 | 16,240 | 14,420 | 13,620 | ..... |
| Barytes (imports) | 1,523 | 2,094 | 1,777 | 2,024 | 1,986 |
| Barytes (exports) | 724 | 125 | 150 | 353 | 381 |
| Spain (production) | 334 | 422 | 476 | 635 | ..... |
| Sweden (imports) | 514 | 529 | 625 | 607 | 644 |
| United Kingdom (production) | 39,572 | 42,436 | 43,637 | 43,232 | 43,453 |
| United States (imports) | 12,390 | 13,301 | 20,203 | 21,195 | 27,093 |
| United States (production) | 34,961 | 36,127 | 37,846 | 37,320 | 42,170 |

It is interesting to note that according to the U. S. Bureau of the Census, 42 mines or quarries of baryte, employing 372 persons, expended in the year 1909 for development and work, $176,967; the value of the product for that year was given by the same authority as $224,766.

IMPORTS OF BARIUM PRODUCTS, 1912.

| Product. | Quantity. | Value. | Declared Value per Ton. |
|---|---|---|---|
| Baryta, sulphate of, or barytes including baryta earth: | | | |
| Unmanufactured tons (2240 lb.) | 23,380 | $52,467 | $ 2.24 |
| Manufactured tons (2240 lb.) | 3,285 | 26,848 | 8.17 |
| Blanc fixe, or artificial sulphate of barytes, and satin white, or artificial sulphate of lime, pounds | 5,599,152 | 70,327 | 25.20 |
| Zinc, sulphide of, white or white sulphide of (Lithopone), pounds | 5,904,475 | 153,303 | 51.93 |
| Barium carbonate, pounds | 1,298,473 | 9,938 | 15.31 |
| Barium binoxide, pounds | 3,895,317 | 253,320 | 129.52 |

Foreign production is stated in the table for the principal countries. Additional notes as to these productions are as follows: At Faleurus, Belgium, the barite deposits are worked, producing an annual amount of 26,000 tons of powder and ground material. About one-half of this is used in Belgium for lithopone. The mines employ 180 workmen, and the washing and grinding plants about 85. The export of lithopone from Antwerp, Belgium, to the United States during the year 1911 was $19,218, and during 1912, $65,975. A factory at Louvain, Belgium, produces annually 16,000 tons of lithopone. German barytes is used.

Germany exported in 1911, 114,264 tons and in 1912 128,452 tons; also 6833 tons of barium white valued $188,972; one-third went to each the United States and Great Britain. The barytes produced in Bavaria, Germany, in 1910 amounted to 24,711 tons, valued at 162,261 marks, and in 1911, 26,234 tons, valued at 167,820 marks. The barytes exported to the United States from Magdeburg was valued $41,765 in 1910 and $7264 in 1911. England imported in 1910 45,425 long tons of barytes worth $655,221 and in 1911, 48,262 tons valued $654,569 while the exports were 8421 tons in 1911 and 11,495 tons in 1910. The increased imports from Germany into England are notable in recent years. The deposits of Germany are described in Richard Bärtling's book[1].

*Consumption.*—The total consumption of barytes in the United States was 70,000 tons in 1912.

The following is an estimate of the consumption of barium compounds and pigments in the United States: Barium carbonate 2100 tons valued at $63,000 barium binoxide 3000 tons valued at $152,400; barium oxide and hydrate 6500 tons valued at $235,000; blanc fixe 10,000 valued at $400,000; barium chloride 2000 tons valued at $65,000; lithopone [illegible] tons valued at $1,500,000; barium nitrate 350 tons valued $38,500; [illegible]alts 500 tons valued at $40,000, making a total tonnage of

[1] [illegible]rstaetten Deutschlands in Geologischen, Lagerstaettenkundlicher und [illegible]dehung, F. Enoke, Stuttgart, 1912.

44,500 tons valued at $2,493,000. Inclusive of barytes, the total value of barium products slightly exceeds $3,000,000 annually. This shows the importance of the industry and with many of the products increasing in demand, the establishment of a few additional plants to replace imports is justified, especially since the profits are good.

*Manufacture of Barium Compounds.*—In the manufacture of barium compounds and pigments, it is the usual practice to use low-grade barytes owing to lower first cost, but this is sometimes balanced by the higher cost of removing impurities from the manufactured product so that it is frequently best to use a better grade of barytes.

The principal processes involved in the manufacture of these products are preliminary crushing and mixing of materials, calcining, lixiviation, filtration, precipitation, filter-pressing or evaporation, drying, reroasting, disintegrating, packing, and weighing. Some of the products require the use of all, others of only part of these processes.

The manufacture of these products are covered by innumerable patents. Few of the patents, however, are of real value, and fewer still are so regarded by the manufacturer; their chief aim usually is to overcome the effect of impurities in the finished product, this being especially true of the lithopone patents. The preliminary removal of impurities, usually by chemical precipitation, from the lixiviated solutions, is necessary for the production of satisfactory barium products.

*Difficulties of Production.*—Under present conditions barytes mining is normally an unprofitable industry, barytes milling is barely profitable, and the manufacturer of barium compounds and pigments quite profitable.

The mining of barytes is perhaps as crude as any mining could possibly be, more than doubling the necessary cost, aside from the usual wasting of most of the gravel product. It bears the same relation to-day as the rock phosphate industry did prior to its present high-efficiency methods. Mining on a large scale with power scrapers, proper washing and preliminary concentrating plants, and tram roads, will prove most effective. Aside from this, rail rates plus the present tariff of $1.50 per ton are insufficient to counterbalance the low cost of river and ocean freight on German and English by-product barytes. Wagon hauls also operate as material drawbacks. To this are added in some instances extravagant methods of operation and high overhead charges.

The failure of milling is primarily due to lack of full consideration of all the factors entering into the production of a high-grade product.

The preparation of the best grade of ground barytes is a problem requiring constant attention, each ore requiring different treatment. The superior white of the best German is due to the purity of the ore and its

having been unacted upon by surface weathering agencies. Primary barytes may be classed in four grades: 1. Pure white barytes; 2. dark hydrocarbon-bearing barytes; 3. barytes containing strontium sulphate; and 4. barytes associated with other minerals, notably fluorspar, calcite, zinc, lead, iron sulphides. Primary barytes is effected by weathering: 1. Deposition of iron oxides, manganese oxide, and clay in seams; 2. leaching of strontium sulphate; and 3. leaching of calcite, blende, etc.

The use of unweathered primary ore while more expensive to mine would cost proportionately less for bleaching. Hand picking and hacking continues the cheapest and most effective method of selecting the best white barytes, and freeing it from the usually associated minerals. Washing removes most of the clay. Iron and manganese oxides are removable by usual bleaching processes, after careful, fine grinding, though frequently the amount of sulphuric acid used is insufficient to effect thorough bleaching (acid being added according to rule of thumb instead of proportionate to the iron and other impurities contained); careful rewashing is necessary to remove *all* the acid. The strontium sulphate-leached barytes while whiter and softer in lump form is, if anything, slightly darker after grinding than unbleached crystalline. The dark hydrocarbon-bearing barytes resists bleaching by chemical methods and while untried, it is suggested that after grinding, roasting sufficiently to volatilize the hydrocarbons, may prove effective. Another help would be the mixture of milk-white and bluish-white with the more colorless barytes.

Various washing arrangements have been tried to assist in overcoming bleaching difficulties, and thus far the Macklind type of washer for ground material appears best. The Point Milling & Manufacturing Co. are, however, to try a new type of washer, the character of which cannot at present be divulged, but it contemplates less space for installation and lower water consumption. There has been some question as to whether the water-floated or air-floated barytes is superior. Microscopic examinations seem to show no superiority of water over air flotation. The imported ground is much coarser than either the water- or air-floated domestic. Economically, it appears that the air flotation process is the preferable one.

Preliminary decrepitation in order to separate blende from barytes more readily is being tried in some of the Missouri mills.[1]

The electrostatic separation has also been suggested.[2]

[1] *Eng. and Min. Journ.*, May 11, 1912, p. 929; June 8, 1912; June 15, 1912.
[2] *Eng. and Min. Journ.*, Dec. 7, 1912.

## Use of Barytes

The chemical properties of barytes or barium sulphate permit of its conversion into oxide, chloride, sulphide, blanc fixe, etc.; admit of its use in the manufacture of alumina; and of glass; and to serve as an important reagent. In glass Barium carbonate facilitates fusion, replaces lead, etc., and gives luster, hardness and increased density.

Its weight and inertness qualify it for use in loading rope, rubber, putty and fabrics; adulterating food, paris green, and fertilizers; preventing aeration of certain cheese; dressing for asphalt pavement surfacing; and filler for wood preservatives.

The texture of its powder or artificial precipitate, its color and inertness combine to make it serviceable in the preparation of white mixed paints, lithopone, and blanc fixe, and as a base for colored pigments; imitation marble; white figures and jasper ware; and in enamels for porcelain, pottery and enamel ware.

From a comparison of the recently published 1912 test fence inspection reports of the Paint Manufacturer's Association certain points regarding the use of barytes and blanc fixe appear of interest:

The best results appear obtainable with up to 10 per cent. inerts of which all may be barytes, or barytes and blanc fixe. The percentage of inerts may be raised to 20 per cent. inclusive of 7 per cent. each of barytes and blanc fixe or say 13 per cent. barytes and the remainder asbestine, and while the general condition will be good there will be medium chalking. The percentage of barytes or barytes and blanc fixe can be increased somewhat without deleterious effects if the percentage of such pigments as basic sulphate of lead, lead-zinc white or zinc oxide be increased and the basic carbonate white lead proportionately decreased. With the percentage of barytes with zinc oxide alone, increased to 36 per cent., the color is usually dark in addition to considerable checking. Lithopone has not yet been successfully applied as an outdoor paint in the United States.

Barytes[1] is the most permanent pigment filler, being unaffected by sulphuretted hydrogen, acids and weak alkalies. One gallon of the dried powder weighs from 15 to 18 lb., according to the fineness. A stiff paste can be made up in a chaser with 93 lb. of barytes and 7 lb. of linseed oil; and in a stone mill with 92 lb. of barytes and 8 lb. of oil. There is no combination of the oil and the barytes, the mixture being mechanical. It is practically indispensable in the manufacture of commercial chrome greens. It has been extensively used as an adulterant, but its function is now better understood, and as long as it does not take the place of a higher priced pigment, is not objectionable.

[1] Abstract from the *Oil Paint and Drg. Reporter.*

In some cases the paint grinders disguise the yellow cast of an inferior product, by the addition of ultramarine blue.

*Artificial Barytes* or Blanc Fixe is more opaque than the natural product, and absorbs twice as much color. A gallon of the powder weighs from 10 to 12 lb. Blanc fixe requires 15 lb. of oil to 85 lb. of the dried powder, or when very fine, 18 lb. of oil to 82 lb. of pigment.

Blanc fixe is made from barium chloride by the addition of sulphuric acid. The precipitate is pressed, washed, dried, and pulverized, or the pulp is washed by decantation and filtered, giving a product containing 70 per cent. pigment, and 30 per cent. water, as sold in the trade.

*Witherite, or Barium Carbonate.*—The properties of this pigment are similar to those of blanc fixe, excepting that it is not unaffected by sulphur gases or acids. It is not a safe pigment to use alone, and one firm in the Middle West, using this material extensively, had to abandon the business. The natural witherite imported into the U. S. in 1912 was worth $25,715.

A pure $BaCO_3$, having only a trace of silica, showed a transition point in roasting at a temperature of 780 to 815°, while decomposition does not occur up to 1100° C.

*Strontianite.*—The value of sulphate of strontium, dug from shallow pits in Gloucestershire and Somersetshire, England, where it is found in the Red Marl of the Keuper Beds, was £4400. The tonnage was 5,869 in 1911. In 1910 4761 tons produced were valued at £13,570.

Strontianite, according to tests made in roasting the mineral,[1] changes when heated to 830° C. but does not actually decompose until a higher temperature than 1130° C. The tests were made on the mineral from Hamm, Westphalia.

*Lithopone or zinc sulphide white* is offered to the trade, being 30 per cent. zinc sulphide and 1 1/2 per cent. zinc oxide; balance precipitated barium sulphate. Lithopone whites showing an analysis of less than 30 per cent. zinc sulphide are inferior grades made by adding barytes, carbonate of lime, gypsum or clay. Lithopone may have a normal percentage of zinc sulphide and yet be rather weak in resistance to color, and this happens when the material has not been finished long enough, retaining some water of combination. This kind of lithopone has a slimy feel under the brush, and is not fit to use in paste whites, but is preferred by shade makers, as it requires a smaller quantity of color to produce tints. It is claimed that some sun-proof lithopone is made, but samples have been offered at a prohibitive price in comparison with zinc-oxide.

Lithopone can be readily ground in a stone mill, preferably of esopus stone. For many purposes it is simply mixed to paste, without grinding

[1] K. Friedrich and L. Garrett Smith, *Metallurgie*, Heft 13, IX, 1912.

in oil. With the chaser apparatus a good workable material is produced, using only 12 lb. of refined oil to 88 lb. of pigment, while with stone mills 14 lb. of oil are required. The blue, yellow seal and black seal lithopone contain less zinc sulphide than do the green and the red seal. In Europe some manufacturers use the latter brands for the product containing 30 per cent. zinc sulphide, and the former brands may denote any percentage from 12 to 24 per cent. By using the higher per cent. grade, the manufacturer can produce any per cent. zinc sulphide by the addition of barytes. Lithopone, before mixing with oil, should be dried so that it does not adhere to a shovel. Care should be taken in cleaning the apparatus previously used for grinding lead.

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# BAUXITE

The only ore of aluminium, is bauxite. This mineral contains up to 70 per cent. aluminium, and as low as 45 per cent. aluminium as mined. Pure alumina as found in nature in the form of corundum is too valuable for this use and does not occur in sufficient quantity. Clay which contains alumina as silicate is by far the most abundant material containing alumina, but, while experiments are being made for the commercial extraction of the metal from this source, the problem cannot be considered as solved for the commercial extraction of either alumina or of the metal from clay.

Bauxite is also a source of aluminium salts. Another natural source for these salts, is alunite, deposits of which are attracting attention on account of the potash contents, and also on account of the alumina which is a by-product. The importance of bauxite depends upon the large uses of the metal aluminium, the consumption of which is increasing. (See article on "Aluminium.") The utility of this metal and the scale of manufacture is being extended so much that this use alone of bauxite makes its mining a permanent industry and the prospects for new deposits are promising. In addition, the uses of bauxite as a refractory and for the manufacture of alundum and electric furnace products, are growing.

In the United States the production of bauxite during the year 1912 can be estimated on the basis of shipments as 160,124 long tons. The following table shows the production divided by fields:

PRODUCTION OF BAUXITE IN THE UNITED STATES.
(In tons of 2240 lb.)

| State. | 1902 | 1903 (a) | 1904 | 1905 | 1906 | 1907 (a) | 1908 (a) | 1909 (a) | 1910 | 1911 (a) | 1912 (a) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Alabama.. | 5,577 | 22,374 | 7,087 | 17,094 | 27,131 | 97,776 | 14,464 | 22,227 | 37,229 | 30,170 | 19,587 |
| Georgia... | 19,000 | | 16,909 | | | | | | | | 14,173 |
| Arkansas.. | 4,645 | 25,713 | 24,016 | 30,897 | 51,200 | (b) | (b)37,703 | (b)106,874 | (b)112,450 | 125,448 | (b)126,105 |
| Total.. | 29,222 | 48,087 | 48,012 | 47,991 | 78,331 | 97,776 | 52,167 | 129,101 | 149,679 | 155,618 | 159,865 |

(a) Statistics of the United States Geological Survey. (b) Production of Tennessee included.

The production is of crude material, and in comparing these figures it must be considered that the shipments are largely of washed material which, of course, is smaller in bulk and tonnage, on account of the removal

of impurities. The following table shows the imports and exports of bauxite into the United States. A notable feature, is the large importation during 1911, which has again fallen to a normal figure in 1912. The imports of this mineral are practically all from France.

The exports of concentrated bauxite from the United States to Canada are increasing and were 7958 tons in 1911, and 10,146 tons in 1912, as reported by the Department of Commerce. The corresponding statistics of Canada, show a larger importation, namely, 17,000 tons in 1911, and 10,550 tons in 1912.

The value per ton of this washed and treated alumina is approximately $40 per ton.

CONSUMPTION OF BAUXITE IN THE UNITED STATES.

| Year. | Production. | | | Imports. | | Exports. | | Consumption. | |
|---|---|---|---|---|---|---|---|---|---|
| | Long Tons. | Value. | Per Ton. | Long Tons. | Value. | Long Tons. | Value. | Long Tons. | Value. |
| 1897 | 20,590 | $51,475 | $2.50 | 2,645 | $10,515 | 2,537 | $5,074 | 20,708 | $56,916 |
| 1898 | 26,791 | 66,978 | 2.50 | 1,201 | 4,238 | 1,000 | 2,000 | 26,992 | 69,216 |
| 1899 | 36,813 | 101,235 | 2.75 | 6,666 | 23,768 | 2,030 | 4,567 | 41,449 | 12,436 |
| 1900 | 23,445 | 85,922 | 3.66 | 8,656 | 32,968 | 1,000 | 3,000 | 31,101 | 115,880 |
| 1901 | (a)18,905 | 97,914 | 4.25 | 18,313 | 66,107 | 1,000 | 3,000 | 36,218 | 144,021 |
| 1902 | 29,222 | 128,206 | 4.39 | 15,790 | 54,410 | *Nil.* | ..... | 43,112 | 175,875 |
| 1903 | (a)48,087 | 171,306 | 3.56 | 14,889 | 49,684 | *Nil.* | ..... | 62,976 | 220,990 |
| 1904 | 48,012 | 166,121 | 3.46 | 15,475 | 49,577 | *Nil.* | ..... | 63,487 | 215,698 |
| 1905 | 47,991 | 203,960 | 4.25 | 11,726 | 46,517 | *Nil.* | ..... | 59,717 | 250,477 |
| 1906 | 78,331 | 352,490 | (e)4.50 | 17,809 | 63,221 | *Nil.* | ..... | 96,140 | 415,711 |
| 1907 | (a)97,776 | 480,330 | 4.91 | 25,065 | 93,208 | *Nil.* | ..... | 122,841 | 573,538 |
| 1908 | (a)52,167 | 263,968 | 5.05 | 21,679 | 87,823 | *Nil.* | ..... | 73,846 | 351,791 |
| 1909 | (a)129,101 | 679,447 | 5.27 | 18,689 | 83,956 | *Nil.* | ..... | 147,790 | 763,403 |
| 1910 | 149,679 | 778,203 | 5.33 | 15,720 | 65,743 | *Nil.* | ..... | 165,399 | 843,946 |
| 1911 | 155,618 | 750,649 | 4.87 | 43,222 | 164,301 | 7,958 | 359,837 | 198,840 | 914,950 |
| 1912 | 160,124 | 900,620 | 5.00 | 26,214 | 95,431 | 10,146 | 456,581 | ..... | ..... |

(a) Statistics of the United States Geological Survey. (e) Estimated.

The imported material pays a freight rate of approximately $2 per ton, in addition to a duty of $1 per ton. The average values of the crude imported product per ton, have been as follows: In 1910, $4.18; in 1911, $3.80; in 1912, $3.65 per ton. A small quantity of alumina or refined bauxite was also imported, namely as follows, during the year 1912: 2,953,088 lb. valued at $47,952, and containing less than 64 per cent. $Al_2O_3$; and 23,032 lb. valued at $1646, containing more than 64 per cent. $Al_2O_3$.

The average prices of bauxite cannot be stated accurately as a number of producers are consumers of their own product. It is undoubtedly true that in the larger mines the method of treatment and mining have been improved in recent years, so that the average costs are reduced.

Prospecting for bauxite is guided by a knowledge of the characteristics of the mineral, and to some extent by the known occurrences now being mined. Conditions under which bauxite occurs, however, are so variable

and its methods of formation so indefinite that it may be expected to occur under other conditions which differ materially from those that are now known.

The properties of the mineral by which it can be recognized in the field are its peculiar concretionary or pisolitic structure. This is sometimes absent, in which case a chemical analysis or tests are required.

The principal producers of bauxite in the United States are Arkansas, Georgia, Alabama and Tennessee.

*Alabama.*—The production of this state is about 6 per cent. of the total in the United States. This field extends from Cherokee County, in the northeastern part of the state, into northwestern Georgia, geology and occurrence in these two localities being similar. Most of the deposits in this field are rounded masses, a few hundred feet in diameter at the surface, tapering at the bottom. They occur in residual clay, derived from dolomite or limestone. These calcareous rocks overlie the shale. It is believed that sulphates originating in the shale were precipitated by the limestone to form the bauxite. The association of limonite and clay is an indication by which further deposits may be found.

*Arkansas.*—Arkansas is the largest producer of bauxite. The production from this field which lies in Saline and Palasky Counties is estimated from shipments in 1912, as about 150,000 tons. The bauxite occurs in beds, resting on kaolinized syenite. The beds are undulating, corresponding to the surface of the syenite, but covering it completely. The maximum thickness is about 30 ft., but it tapers and may be absent entirely where the country is cut by ravines. The texture of the ore may be pisolitic or clayey, or it may be of the same texture as the syenite. Though rocks similar to this underlying syenite are found in other localities of the United States, no bauxite ore is known to be associated.

The six mines of the American Bauxite Company ship their material from Bauxite, on the Bauxite and Northern Railroad, which is a spur from the St. Louis, Iron Mountain and Southern, and which crosses the Rock Island tracks at Bauxite. Three grades of ore are mined, that containing less than 2 per cent. ferric-oxide being used for aluminium salts, and that carrying 6 to 7 per cent. silica, but pure from iron, for alundum, the ferruginous ore being used for the manufacture of metallic aluminium. The grade of the ore is constantly regulated by assays. The stripping may be from 10 to 50 ft., and considerable ore is recovered from this overburden by washing. The ore which is then mined in benches is crushed, depending on whether it is dry in a Gate's crusher or whether sticky from moisture in revolving crushers which revolve in opposite directions. The ground ore is dried in cement kilns. The recent introduction of natural gas from the Caddo field in Louisiana, and

of electrically driven machinery, has simplified operations. Another operator is the Republic Mining and Manufacturing Company of Philadelphia, Pa.; these companies also operate in Alabama and Georgia.

An analysis[1] of washed calcined bauxite for Arkansas is as follows:

| | |
|---|---|
| Mechanical water | 0.88 per cent. |
| Silica | 6.40 per cent. |
| Iron oxide ($Fe_2O_3$) | 1.43 per cent. |
| Alumina ($Al_2O_3$) | 87.30 per cent. |
| Titanium oxide ($TiO_2$) | 3.99 per cent. |

*Georgia.*—The production from Georgia in 1912, is estimated at about 30,000 tons. The field which is a continuation of the Alabama field, lies chiefly in Barton and Floyd Counties. Deposits of bauxite are also known in Wilkinson County, central Georgia. These, however, are entirely different geologically, and lie 30 miles west of Macon. The bauxite apparently occurs at the flat contact between lower Cretaceous and the Claiborne group (Eocene). The former clays contain the ore as nodules, or the beds lie directly upon the clays. It is supposed that this ore originated from the alteration of an intermediate clay bed. The ore is generally hard and varies from white to bright red. The bauxite has been found wherever the white clay beds locally known as "chalk-beds," are in contact with the overlying red sands and impure clays.

The following analyses were made by Edgar Everhart, of the Geological Survey of Georgia.

ANALYSES OF WILKINSON COUNTY BAUXITE.

| $Al_2O_3$. | $Fe_2O_3$. | $SiO_2$. | $TiO_2$. | $H_2O$. | Moisture. |
|---|---|---|---|---|---|
| 52.92 | 7.66 | 10.17 | 2.30 | 26.55 | 0.35 |
| 57.58 | 0.96 | 9.38 | 2.76 | 29.12 | 0.35 |
| 41.97 | 18.24 | 17.50 | 2.65 | 16.83 | 2.65 |
| 57.36 | 1.94 | 0.90 | 3.65 | 32.44 | 0.67 |
| 42.73 | 14.99 | 15.57 | 1.84 | 20.29 | 2.79 |
| 61.77 | 1.67 | 0.90 | 2.26 | 31.77 | 0.95 |

*Tennessee.*—The deposits of Tennessee which are similar to the last, are on the southern slope of Missionary Ridge, near Chattanooga. The conditions are the same as those described in Alabama, and the ore is found in the Knox dolomite near the fault line, along which it has been overthrust upon the Chickamauga and Clinton formations, lying to the northwest. This area has been expanded by the discovery of additional deposits beyond those originally known.

In June, 1912, the International Bauxite Company started a new mine which is 200 miles north of any bauxite mine which has yet been operated. This mine is located 1 mile northeast at Keenburg, a station

[1] S. R. Stone, *Min. and Eng. Wld*, Vol. XXXVII, Aug. 24, 1912, p. 342.

on the Virginia and Southwestern Railroad, and about 4 miles due north of Elizabethtown, the county-seat of Carter County. The deposit is similar geologically to those of the Georgia-Alabama area. The underlying rocks are Cambrian or Ordivician, and include the Athens shale, Knox dolomite, Honaker limestone, Erwin quartzite, Shady limestone and the Nolichucky shale. These strata are much folded and faulted, there being one major and three minor faults. The altitude of this locality is about 2000 ft., whereas the altitude in the Alabama district is only 900 ft. An analysis of the ore[1] is as follows: Insoluble, 18.38 per cent;. $Fe_2O_3$, 4.13 per cent.; $Al_2O_3$, 49.90 per cent.; $H_2O$, 27.59 per cent. A small drying plant has been constructed at the railroad about three-fourths of a mile from the mine. As geologic conditions are similar to the northeast and southwest of Keenburg, other workable deposits are likely to be discovered.

*Alunite.*—Alunite ($K_2O.3Al_2O_3.4SO_3.6H_2O$) is associated with many of the Western ore deposits. That at Marysville, Utah,[2] the largest in the United States, and that of Goldfield, Nev., are examples, although in the former case the metallic ores have not been found workable. Other examples are in the Rosita Hills, in the Rico Mountains, at Silverton and Cripple Creek, Colo., and at Tres Cerritos, Calif., in the Clifton Morenci district, Arizona and in Beaver County, Utah.

The deposits of alunite of the San Cristobal Quadrangle, Colorado, are described by Esper S. Larsen.[3]

The rocks of this region range from rhyolite to basalt. Even the latter contain considerable amounts of potash feldspars. Where these rocks are altered they become soft and usually white. While some of the alteration produces kaolinite or sericite, it appears that alunite is the more common product. Associated minerals in this product are a little pyrite and occasionally bauxite. The area at the head of Middle Fork of Piedra River has considerable faulting. In the southeastern part the altered rock contains sulphur but no alunite. The area at the head of South River, east of Piedra, covers approximately 1 square mile. The rock contains approximately 69 per cent. of quartz, 2 per cent. of pyrite and 29 per cent. of alunite. It is estimated that more than half of the potash and soda of the original rock is lost in the alteration and so is nearly all the magnesia and lime. Some of the alumina is also lost, but there is little change in the total iron and silica. The area of Red Mountain, a few miles south of Lake City, is covered by rock very rich in alkalies. The largest body of altered rock covers 1 sq. mile on the slopes and top of Red Mountain. Inasmuch as sulphates are found in some of the sul-

[1] By H. E. Graves, Bristol, Tenn.
[2] *Bull* 511. *U. S. Geol. Surv.*, 1912.
[3] *Bull.* 530, p. 179, *U. S. Geol. Surv.*, 1913.

phide veins of the region,[1] the evidence suggests hot ascending solutions as the cause of alunitization. The evidence, however, is not sufficient.[2]

## Foreign Countries

*Belgium.*[3]—Bauxite is used at Selzaete for the manufacture of salts of aluminum and pure alumina by the Peniakoff process. Seventy thousand tons of raw material are annually used, and it comes from the Var deposit in France. This process uses sodium sulphate instead of carbonate, for transforming the mineral into soluble sodium aluminate. This produces the best grade of alumina at a low cost. The solution after precipitating with carbon dioxide is used for making caustic and sal soda.

The paper mills use aluminum sulphate for sizing, and this is now prepared directly from crude bauxite. The bauxite is heated in an iron kettle with sulphuric acid, under pressure. The solution of 30° Baume, is settled and decanted, concentrated to 42° and allowed to solidify after a few days. The iron is removed by bleaching powder and ferrocyanide. The final solution is evaporated to 52° Baumé. The factory treats 2 1/2 tons of bauxite by this process each day, and produces 4.7 tons of aluminum sulphate free from iron; 4.4 tons of sulphate containing 0.02 per cent. iron, and 0.86 tons of potash alum. The costs are respectively $12.50, $11.19, and $19.28. The bauxite costs $7.62 per ton. Most of the product is exported.

At Ampsin, Belgium, aluniferous schists are employed for making potash alum. At Ruysbrock, potash alum is made from alunite imported from Tolfa, Italy. The annual production reaches 1800 tons, but competition with English works is becoming difficult on account of extended uses of aluminum sulphate as a mordant.

Belgium imported 6932 tons of bauxite from France in 1912.

*Canada.*—The alumina imported from the United States into Canada was 17,653 long tons valued $353,872 for the fiscal year ending March 31, 1911. The figures for 1912 were 10,550 tons, valued $421,857; for 1913, 13,122 tons, valued $525,017. There were practically no imports from France and none from other countries. Canada exported 2495 tons of aluminium in the calendar year 1912, valued $747,587, and 9143 tons in 1912, valued $2,002,363.

*France.*—In 1912 France exported 143,843 tons of bauxite for the manufacture of aluminium, and in 1911, 154,218 tons and 114,314 tons in 1910. Production in the Province of Var is increasing, although the

[1] Esper S. Larsen, Jr., and Schaller, W. T., Hinsdalite, "A New Mineral," *Am. Journ. Sci.*, 4th ser., Vol. XXXII, 1911, p. 251; Irving, Bancroft and Howland, "Geology and Ore Deposits near Lake City Colo." *Bull.* 478, *U. S. Geol. Surv.*, 1911, p. 54.

[2] Butler, B. S., and Gale, H. S., "Alunite, a Newly Discovered Deposit near Marysvale, Utah," *Bulletin* 511, *U. S. Geol. Surv.*, 1912, p. 21.

[3] Special Consular Report, No. 65.

stock at the commencement of 1912 was 500,000 tons, the sales in 1912 being 210,000 tons. A factory for making emery by calcining rich bauxite has been built at Cannet-de-Lac. The Bouches-du-Rhone deposits are large, but rarely contain over 54 per cent. aluminium and the production has been only about 7000 tons.

Red bauxite used for manufacturing anhydrous alumina was exported in 1911 to the amount of 8802 tons.

The bauxite exported as declared at Marseille, France, to the United States was 754 tons in 1911 and 28,987 tons in 1912. The exports from Toulon, France, were 30,136 tons. The value of that exported to the United States was $49,015. The total value of the bauxite declared and exported from Cette in 1912, was $13,900 and in 1911, $55,125.

The bauxite from France goes chiefly to England, the United States and Germany. It is lower in silica than the American but much higher in iron contents.

*Germany.*—The production of bauxite in Germany was small, but the imports were 37,155 tons in 1911 and 36,350 tons in 1912. The amount of bauxite from France in 1911 was 25,611 tons.

*Italy.*—The production of bauxite in Italy, was as follows: 1910: 4595 tons, valued at 45,950 lires; 1911: 5690 tons, valued at 63,728 lires.

There is but one producing mine. A description of the deposits at Pescosolido is given in MINERAL INDUSTRY, Vol. XX, p. 97.

*United Kingdom.*—The bauxite obtained in Ireland, County Antrim, at Ulster, amounted to 6007 tons in 1911, valued at £1294. The deposits occur in the form of seams lying between sheets of Tertiary basalt. The alumina is prepared nearby at the works at Larne. Four mines are being worked. The bauxite imported from France was 40,000 tons in 1911.

## USES OF BAUXITE AND ALUMINA

The mineral bauxite is used for the manufacture of aluminum, there being required 6 tons each of bauxite, coal and limestone to make 2 tons of alumina, from which 1 ton of aluminum is made. The Aluminum Company of America produces its product at East St. Louis, Ill., which is the best point of freight haul for the raw materials. One important raw material used is "carbon," made from petroleum coke. The reduction process is slow and complicated and requires a large investment. The bauxite is valued at $5 per ton, and the investment required for every ton of aluminum turned out amounts to $1500. The interest alone amounts to 4 1/2 cents per pound of aluminum. The petroleum coke is worth about $5 per ton, but the finished carbons as used cost about $50 per ton.

*Alumina for Drying Gases.*—The use of alumina as a dehydrating

agent for gases which act upon phosphorus pentoxide is suggested by F. M. G. Johnson (*Journ. Am. Chem. Soc.*, July, 1912). The alumina is prepared from the hydroxide, and is effective until it gains 18 per cent. of its weight, corresponding to $Al_2O_3.H_2O$.

*Bauxite in Cement.*—The addition of bauxite to cements is stated to allow regulation of the time of setting and of the resistance (Fr. pat. 437,860). The bauxite is also stated to stabilize the lime in them, and to produce a quick setting, highly resistant product. The bauxite cements, as well as addition products with lime and plaster, are covered by the patent, as are also the processes of manufacture.

*Bauxite Brick for Furnace Lining.*—Sir William Siemens observed that even impure bauxite (with 35 per cent. $Fe_2O_3$) as used for brick will outlast clay fire brick in a furnace. After exposure to intense heat it becomes hard (emery) and cannot be easily chiselled. Since pure grades of bauxite are available many experiments have proven its suitability, for example in cement kilns. The hardness of the brick for this purpose should be such that it will not allow the cement coating to stick to its surface, nor allow the coating to peel off. The coating incidentally forms a protection for the brick. The brick used in the hot zone of a cement kiln was 6 in. thick, and the zone extended for 10 or 12 ft. The hearth of a lead furnace 10 by 13 ft. was lined with 9-in. bauxite brick set on end, the sides being lined with one course of the same brick. The temperature of this furnace, 1300 to 1400° F., is not high enough to act destructively on the brick, but the chemical action in the furnace, due to arsenic, antimony and other oxides, is very severe. On account of no silicates being present and these also being avoided in the joints, the basic slag did not form lower silicates which would eat away the brick. It was found that bauxite brick lasted five or six times as long as the usual fire-brick lining.

For basic open-hearth steel furnaces, a white bauxite which has been washed at the mine is screened, all the fine material being rejected. The remaining pebbles of pea size contain less silica and are bonded with lime into a brick. Such a brick can be made containing as low as 6 to 8 per cent. silica. Tests made of magnesite brick and of bauxite brick near the gas and air ports have shown that the bauxite brick did not become viscous for 15 minutes, whereas the magnesite became so in seven minutes. The absorption of the basic slag also was not as great with bauxite brick as with the magnesite. Tests with bauxite brick covered with a hearth of granular bauxite in the same manner as magnesite hearths are prepared, have not yet been made. The preparation of material in general for furnace lining is to remove some free silica by screening or selection of the crude material, and calcining at a

temperature of 2500° F. Raw ore loses about 30 per cent. of the chemical water and shrinks considerably. The greatest amount of shrinkage in bauxite brick takes place between the temperatures of 2390 and 2500° F. When bricks are bonded with lime they become quite hard a few hours after making, probably due to reaction between the lime and the free silica. The brick after careful drying, are burned at high temperature. A brick 9×2 1/2×4 1/2 in. weighs 7 1/2 lb. It has a crushing strength of 10,000 lb. per square inch. The calcining of the crude bauxite is usually done in a rotary kiln and preferably at the mine.

*Aluminium Nitride from Bauxite.*—A description of the Serpek process[1] states that it is being tried on a large experimental scale in France. Pure alumina results as a by-product in this process, which heats calcined bauxite with carbon. The alumina is not as advantageous as the crude bauxite, but it can be used in the manufacture of aluminium.

## Properties of Bauxite

The melting-point of bauxite bricks as determined by C. W. Kanolt,[2] is 1740° C. It is unaffected by previously heating. Bauxite bricks are made from bauxite, $Al_2O(OH)_4$ that usually contains impurities as mined. Pure alumina melts at about 2010° C. Bauxite melts at 1820° C. and bauxite clay at 1795° as determined on specimens.

| | Temperature of Firing. | Pounds Weight per Cubic Foot. | Temperature. | "r" |
|---|---|---|---|---|
| Alundum | ..... | 118.0 | 600 | 40.9 |
| | ..... | 149.0 | 600 | 67.9 |
| | ..... | 127.0 | 600 | 37.6 |
| Bauxite | 1050 | 118.0 | 1000 | 30.0 |
| | 1300 | 120.0 | 1200 | 28.0 |
| Red brick | 1050 | 121.0 | 1000 | 34.0 |
| White brick | 1050 | ..... | 1000 | 25.0 |
| Carborundum | 1050 | ..... | 1000 | 6.5 |
| | 1300 | ..... | 1200 | 4.1 |
| Checker brick | ..... | 112.0 | 1200 | 25.0 |
| Chromite brick | 1300 | ..... | 1200 | 38.0 |
| | ..... | 128.0 | 1200 | 17.0 |
| | ..... | ..... | 1200 | 14.0 |
| Chromite and clay | 1050 | 144.0 | 1000 | 34.0 |
| | 1300 | 155.0 | 1200 | 28.0 |
| Fire-brick | 1050 | 111.0 | 1000 | 25.0 |
| | 1300 | 120.0 | 1200 | 18.0 |
| | 1050 | 111.0 | 1000 | 27.0 |
| | 1300 | 178.0 | 1200 | 22.0 |
| Glasspot brick | green | 110.0 | 600 | 30.0 |
| | 1200 | 116.0 | 1200 | 38.0 |
| | 1600 | 122.0 | 1200 | 21.0 |
| Kieselguhr-brick | ..... | 64.4 | 1200 | 52.0 |
| Magnesia brick | 1050 | 125.0 | 1000 | 16.0 |
| | 1300 | 125.0 | 1200 | 14.0 |
| Magnesia and clay brick | ..... | 126.0 | 1200 | 32.0 |
| | ..... | ..... | 100 | 38.0 |
| Retort brick | ..... | 116.0 | 1200 | 25.0 |
| Silica brick | 1050 | 98.5 | 1000 | 47.0 |
| | 1300 | 93.5 | 1200 | 30.0 |

[1] J. W. Richards, *Met. and Chem. Eng.*, Vol. XI, p. 139.
[2] *Bureau of Standards*, Washington, D. C., *Eighth Int. Cong. Appl. Chem.*, Vol. XXII, p. 179.

The heat flow through bauxite bricks fired at 1050° C. is about the same average for various kinds of brick of refractory materials. The foregoing table gives the resistivity of refractories to heat flow in watts and measured in centigrade degrees per watt per cubic inch.[1]

*Alumina from Clay.*—The recovery of alumina from clay has been suggested and experimented upon by D. H. Childs[2] (U. S. patent 1036454). Alumina fluoride (prepared according to United States patent 1036453) is added to clay so that one atom of silicon in the clay has four of fluorine. The mixture is heated to redness in the presence of water-vapor. Silicon fluoride passes off and alumina is left. The resulting $SiF_4$ reacts with steam and water spray, the silica being separated by centrifugal action. The HF liberated is washed with water in a tower filled with clay. The acid solution from the tower is treated with excess of mildly calcined clay, precipitating the excess of silica, much of the iron and titanium and regenerating the aluminium fluoride. Two-thirds of the alumina is thus obtained from the calcination of aluminium fluoride. It is claimed that half the titanium and more than half the iron are volatilized with silica in the calciner. In the laboratory 80 to 90 per cent. of the fluorine is recovered. Considering 80 per cent., the cost per ton can be figured as $17. Experiments on a larger scale are to be made. Attempts have also been made to obtain the necessary fluoride from the gases given off in the manufacture of phosphate.

*Alumina from Clay, Cowle's Process.*[3]—The most important development in the solution of the problem of obtaining alumina from clay is the process which is being tried out at Sewaren, N. J., by Alfred H. Cowles. Dr. Kayser in the early nineties attempted to produce an alkali-silicate from aluminous silicate, such as feldspar or clay. By moulding the raw material into hollow bricks containing carbon in addition to the salt which furnishes the sodium, it was found that the reaction took place with greater rapidity and could be made a continuous process. In the experiments thus far conducted, clay, salt and sawdust are mixed together in a batter which is moulded into hollow bricks in a briquetting machine. These briquets are loaded on to flat cars 12 ft. long and 5 1/2 ft. wide. A procession of cars passes through a drying furnace, where the water is driven off, and then by a transfer track into a vestibule connected with a long kiln.[4] The problems of cooling the gases and simplifying the elimination of dust, lead to the adoption of this Gröndal type of furnace. A sand seal is used and extends the whole length of the furnace and air is blown

[1] C. P. Randolph, General Electric Research Laboratory, Gt. Barrington, Mass., *Gen. El. Rev.* Feb. 13.
[2] *Eighth Int. Cong. Appl. Chem.*, Vol. II, p. 67, and Action of some fluorine compounds on clay, water, etc., Vol. XXV, p. 115; *Met. and Chem. Eng.*, Vol. XI, No. 5.
[3] *Met. and Chem. Eng.*, Vol. XI, p. 140.
[4] *Met. and Chem. Eng.*, Vol. X, p. 660.

under the cars in order to prevent leakage of the hydrochloric-acid fumes produced. The reaction varies according to the composition of the material used, and the amount of alkali chloride mixed therewith, but may be written typically as follows:

$$Al_2O_32SiO_2+4NaCl+2H_2O+yH_2O+zC-zO=(Na_2O)_2(SiO_2)2Al_2O_3+4HCl+yH_2O+zCO.$$

An extensive acid condensing apparatus with air cooling is used. The experiments prove that the briquets were a little more than half converted. In the laboratory briquets had been made as high as 33 per cent. sodic-oxide and were white and free from iron.

The process of Dr. Kayser, for rendering the resulting alkali-silico-aluminate leachable, consisted in sintering the product together with enough lime to completely satisfy the silica. This process was acquired by the Cowles Company. The reaction involved is as follows:

$$(Na_2O)_2(SiO_2)2Al_2O_3+4CaO=2((CaO)_2SiO_2)+(Na_2O)_2+Al_2O_3.$$

Limestone may be used instead of anhydrous-lime. The soluble alkali aluminate is leached by ordinary methods. In the reaction an excess of lime means the formation of an insoluble aluminate, and an insufficiency of lime does not decompose the sodic-silico-aluminate, thus causing a loss either way. When briquets are made containing 32 per cent. sodic oxide, the output of 33 per cent. hydrochloric acid should be about 1 3/4 tons for every one ton of salt in the charge. It will be noted that the by-product of dicalcium silicate, if calcined and ground and heated with additional lime, produces hydraulic cement. Such cement of a gray color has been actually produced. The dicalcium silicate also by the addition of alkali would be quite suitable for bottle-glass and window-glass manufacture. The impurities of ferric-oxide and alumina would not be detrimental.

The recovery of alumina in pure form is accomplished chiefly by means of the Dr. K. H. Bayer's process, which was patented in 1894. Previously precipitated alumina is added to the aluminate solution, and by an added step the last traces of alumina are precipitated, the solution containing nothing but caustic-soda which requires but little concentration to prepare it for the market.

### Alumina from Alunite

The mineral, $K_2O.3Al_2O_3.4SO_3.6H_2O$, when ignited loses all the water and three-fourths of the sulphuric acid. The leached residue consists of $Al_2O_3$. According to W. T. Schaller 32.7 per cent. of the

ignited mass consists of potassium sulphate; the balance is alumina. See also MINERAL INDUSTRY, XX, pp. 617 and 99.

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# BISMUTH

No bismuth ores have been mined in the United States in recent years. During 1911 some bismuth ore was sold for its gold and silver contents, and a few tons of rich bismuth ore was shipped for experimental purposes. These ores came respectively from the Comstock mine, La Plata, La Plata County, Colorado, and from a claim southwest of Tularosa, New Mexico.[1]

The bismuth produced in the United States, therefore, in 1912 was entirely from the residues obtained in the refining of lead. The chief producer is the United States Refining Company, at Grasselli, Ind. Other companies have been making experiments on producing bismuth as a by-product. These are the American Smelting & Refining Company at the Omaha plant, and the United States Metals Refining Company at Chrome, N. J., and also the Perth Amboy plant of the American Smelting and Refining Company. So far as is known, however, no production was marketed in 1912. The first plant mentioned above obtains the bismuth from the slimes from the electrolytic refining of lead by the Bett's process. The processes used by the other firms are not made public.

It is probable that 3000 lb. of bismuth are wasted per month with the smelter smoke from the stacks of the various smelteries of the United States. Bismuth being an undesirable constituent of lead must be separated. As the domestic consumption is supplied almost entirely from European markets, the production in the United States as the number of plants increase can supply only a fractional part of the total. The following table gives the imports of metallic bismuth for recent years:

| Year. | Quantity. | Value. |
|---|---|---|
| 1904 | 185,905 | $339,058 |
| 1905 | 148,589 | 318,007 |
| 1906 | 254,733 | 318,452 |
| 1907 | 259,881 | 325,015 |
| 1908 | 164,793 | 257,397 |
| 1909 | 183,413 | 286,516 |
| 1910 | 198,174 | 332,668 |
| 1911 | 172,093 | 311,771 |
| 1912 | 182,839 | 316,440 |

[1] Reported by the United States Geological Survey.

Imported bismuth in 1912 was $1.72 per pound. As bismuth is imported free, the domestic bismuth was sold at about the same price. The price of bismuth the world over is controlled by the European convention. The production is monopolized with the exception of the by-product bismuth in the United States. The price fixed by the convention during 1911 and 1912 at London was 7s. and 6d. per pound.

The production of bismuth in the United States was about the same during 1912 as in 1911. As it is probable that more producers will be on the market in 1913, the production will increase.

The largest producer of bismuth is Bolivia. This country produced more than all the other countries combined. The bismuth is mined in the same region as the tin lodes. The principal mine is in the "Tazna" district. The ores include native metal, carbonate, sulphide and ochre. The bismuth content is from 20 to 30 per cent.; the iron 10 to 17 per cent.; sulphur 9 to 12 per cent. Analyses of the crude bismuth obtained from this ore are given in the table. Other districts from which bismuth ore is obtained are the Huayna-Potosi, La Paz and Chorolque. The ore from Tazna is smelted at Quechisla. The products are metallic bismuth and a copper matte containing 5 per cent. bismuth. The Government imposes an export duty of $4 per hundred-weight of ore. The exports of bismuth are reported as 414.5 tons in 1911, and 387.7 tons in 1912. It is claimed that the annual exports of ore are about 100,000 tons, but correct statistics are not available. The value in 1912 was $784,183.

In Peru deposits have been worked near San Gregorio, Cerro de Pasco. The bismuth refined in Peru is reported as 30,000 kg. in 1909, 24,136 kg. in 1910, and 24,000 kg. in 1911.

*Bismuth in Other Countries.*—In Mexico the Rey del Bismuto works an important deposit in Sinaloa. The Belen mine in Sonora, and the Mariposa mine in Sinaloa, are also factors in Mexico's output of high-grade bismuth ores. Smelting has been attempted on low-grade ores containing only 2 per cent. bismuth; of these there are large quantties. Rich oxidized ores have been obtained near Ojo Caliente, Chihuahua.

In Canada native bismuth is said to be of common occurrence in the sluice boxes on the Stewart river on the Yukon. Bismuth also occurs in the Montreal River district. Bismutite occurs at New Ross, Lunenberg County, with tin, tungsten, and molybdenum. The mineral also occurs in quartz veins near Kewagama Lake, Quebec, and near Lyndock and Clarendon, Ontario. The value of the bismuth imported in 1910 was $6996, and in 1911 $7012.

The bismuth ore exported from Australia in 1912 was 610 cwt. valued at £4641. The production of Tasmania was, in 1912, 7.59 tons of bismuth,

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valued at £2646, and in 1911, 14.395 tons valued at £5758. The production of bismuth from Queensland in 1911 was 9 3/4 tons valued at £5525 and in 1912, 5.95 tons valued at £2835; in addition, the bismuth and tungsten ore was 129 tons valued at £11,564 in 1911, and 191 1/2 tons, valued at £16,426 in 1912. The bismuth ore and metal produced in New South Wales in 1911 was 7.9 tons, valued at £1800, and in 1912 5.8 tons valued at £1210. In 1911, the mixed tungsten and bismuth ore produced in Victoria at Bendoc amounted to 15 1/2 cwt., valued at £239. In Victoria the deposits discovered in 1910 at Round Hill, Bendoc, and containing wolframite, shipped ore and are now being worked. In New South Wales the production in recent years came from Kingsgate near Glen Innes, and Whipstick near Panbula. The bismuth deposits at the former place are found in nearly circular pipe veins at the junction of granite slates. These pipes are from 10 to 50 ft. in diameter. The ore is associated with molybdenite. The bismuth content of the pipes is from 1/2 to 5 per cent. bismuth. The concentrate contains 69 per cent. bismuth. In the Whipstick deposits the wolframite is generally absent, but otherwise they are similar to those of Kingsgate. The bismuth mines in Queensland have been described in the Bulletin of the Imperial Institute (1912, 10, 330). Deposits also occur in the Chillagoe district. One occurrence has been worked in the Degilbo district. This is a 3-ft. lode containing bismuth carbonate, sulphide and telluride associated with copper. A specimen assayed 3.6 per cent. bismuth; 12.1 per cent. copper and 5 oz. of silver. The amount of bismuth from South Australia for recent years has been insignificant. The occurrences are described by H. Y. L. Brown.[1] The production from Tasmania comes from the Shepherd and Murphy mine. The ore is associated with wolframite and cassiterite. The following table shows the value and production of bismuth in Queensland in New South Whales:

PRODUCTION OF BISMUTH MINERALS IN AUSTRALIA.
(Tons of 2240 lb.)

| | Queensland. | | New South Wales. | |
|---|---|---|---|---|
| | Tons. | Value. | Tons. | Value. |
| Previous to 1903..... | 345.0 | £66,285 | 483.0 | £64,535 |
| 1903..... | 11.0 | 2,523 | 21.7 | 9,537 |
| 1904..... | 20.9 | 3,581 | 40.3 | 12,329 |
| 1905..... | 15.3 | 5,368 | 55.8 | 20,763 |
| 1906..... | 6.5 | 1,882 | 25.9 | 5,700 |
| 1907..... | 6.3 | 1,806 | 16.3 | 5,268 |
| 1908..... | 22.7 | 10,595 | 8.7 | 2,017 |
| 1909..... | 10.3 | 2,271 | 8.6 | 1,624 |
| 1910..... | 21.0 | 9,708 | 6.4 | 2,004 |
| 1911..... | 9.8 | 5,525 | 7.9 | 1,800 |
| 1912..... | 5.0 | 2,835 | 5.8 | 1,210 |

[1] Record of Mines of South Australia, 1908.

In Japan bismuth has been produced, but none was reported since 1909. In 1903, 168 kg., and in 1908, 356 kg. were reported. In Spain two bismuth mines were working in 1911. The production of ore was 52 tons in 1911 valued at 22,895 pesetas at the mine. In Norway one mine, the "Kjenner Bismuth" between Kristiania and Drammen, is worked for bismuth ore. The production in 1912 is said to be 50 tons of ore containing 50 per cent. bismuth. Much of the world's bismuth was obtained for many years from Saxony. The cobalt veins of Schneeberg contain quantities of native bismuth. In Rhodesia many occurrences of bismuth are recorded. Bismuthinite occurs at the Hay mine, Mazoe, associated with molybdenite and pyrrhotite; the bismuth is not recovered.

*Metallurgy.*—The concentration of bismuth ores is seldom attempted in the wet way; usually a liquation process is preferred. In New South Wales the ores are treated in sluice boxes, and a concentrate of 20 per cent. bismuth is obtained. After the molybdenite is picked out from this product the ore is again treated in a smaller sluice box, resulting in a 50 to 60 per cent. bismuth concentrate. Vanners, tables and electromagnetic separators are also used.[1]

The crude bismuth obtained from smelting the ore, contains most of the lead, gold, silver and antimony, the copper forming a matte. The following table gives the analysis of crude and refined bismuth from different localities:[2]

| | Crude Bismuth. | | | Refined Bismuth. | |
|---|---|---|---|---|---|
| | Australia. | Bolivia. | Peru. | Saxony. | |
| | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. |
| Bismuth | 96.2 | 99.05 | 93.57 | 99.74 | 99.98 |
| Antimony | 0.8 | 0.56 | 4.57 | ..... | ..... |
| Arsenic | trace | ..... | ..... | 0.01 | trace |
| Copper | 0.5 | 0.26 | 2.06 | 0.02 | 0.03 |
| Lead | 2.1 | ..... | ..... | 0.11 | 0.06 |
| Iron | 0.4 | ..... | ..... | trace | trace |
| Sulphur | ..... | ..... | ..... | 0.04 | ..... |
| Silver | ..... | 0.08 | ..... | 0.07 | ..... |

The refining of the crude bismuth is done in a similar manner to that of lead, the impurities being removed by oxidation.

Wet processes of extraction from the ore consist in treating the ore with hydrochloric acid and precipitating the bismuth dissolved either by water or iron. The precipitate is then reduced to metallic bismuth by means of smelting with carbon.

A process for treating carbonate ore is described by F. W. Frerichs.[3]

[1] Annual Report of the Minister of Mines for Queensland (1909, p. 95).
[2] From the *Bulletin of the Imperial Institute*, 1912, p. 638.
[3] *Proceedings Am. I. Chem. Engineers*, 1911, p. 90.

The uses of bismuth are chiefly in alloys in anti-friction metals, electric fuses, solders, stereotype or type metal, and chemical compounds some of which are used in medicine. Molten bismuth, on cooling, expands about 2.3 per cent. of its volume. This property makes it valuable in type metal. The molten bismuth cooled 6° C. below its melting point remains a liquid and again rises in temperature on solidifying. The conductivity is very low, being only 2 per cent. of that of silver. Fusible alloys are made of about 50 per cent. bismuth on account of its very low melting point. With cadmium and tin the melting point may be as low as 70° C. A composition of 50 per cent. bismuth, 13 per cent. tin, 10 per cent. cadmium and 27 per cent. lead melts at 60° C.

# BORAX

This subject was covered exhaustively in Vol. XX of THE MINERAL INDUSTRY. The domestic output of crude material comes exclusively from California, and is converted into borax and boracic acid in San Fransisco, Cal. and Bayonne, N. J. The foreign commerce of the United States in boracic materials is of small importance, as indicated below:

UNITED STATES IMPORTS OF BORAX, ETC.
(Fiscal Years ending June 30.)

| Year. | Borax. | | Borate of Lime, Etc. | |
|---|---|---|---|---|
| | Pounds. | Dollars. | Pounds. | Dollars. |
| 1908 | 1,964,792 | 67,851 | 2,640 | 132 |
| 1909 | 341,058 | 13,173 | 1,646 | 167 |
| 1910 | 9,058 | 1,479 | 19,201 | 1,855 |
| 1911 | 7,319 | 790 | 13,095 | 2,277 |
| 1912 | 6,409 | 604 | 22,784 | 3,856 |

Two of the important producing countries are Chile and Turkey, late statistics from both of which are not available.

*California.*—Practically the entire output of boracic material in the United States now comes from two mines in California: That of the Pacific Coast Borax Co., at Ryan, Inyo County, and that of the Sterling Borax Co., at Lang, Los Angeles County. In both cases, the material mined is colemanite, the borate of lime. The older deposits of marsh or dry-lake borax are now almost completely overshadowed by the much richer and more easily accessible colemanite deposits. Shipments from the Lila C. mine, at Ryan, average 40 per cent. boric acid. A description of the deposits at this locality was given in the *Mineral Resources of the United States* for 1911, Part II, p. 861. Renewed attention is being

PRODUCTION OF BORATE ORES IN CALIFORNIA. (a)
(In tons of 2000 lb.)

| Year. | Tons. | Value. | Year. | Tons. | Value. | Year. | Tons. | Value. |
|---|---|---|---|---|---|---|---|---|
| 1901 | 7,221 | $ 982,380 | 1905 | 46,334 | $1,019,158 | 1909 | 16,628 | $1,163,960 |
| 1902 | (b)17,202 | 2,234,994 | 1906 | 58,173 | 1,182,410 | 1910(d) | 37,000 | 1,950,000 |
| 1903 | 34,430 | (c) 661,400 | 1907 | 53,412 | 1,200,913 | 1911(e) | 53,330 | 1,569,151 |
| 1904 | 45,647 | (c) 698,810 | 1908 | 22,200 | 1,117,000 | 1912(e) | 42,315 | 1,127,813 |

(a) Reported by the California State Mining Bureau. (b) Mostly refined borax, whence the apparent discrepancy in value. Output of the other years is given as crude material. (c) Spot value. (d) Crude. From *Eng. and Min. Journ.* (e) U. S. Geol. Survey, crude.

given to the possibility of extracting borax from the brine wells at Searles Lake, by a process which will yield potassium chloride as by-product. In 1912, the Foreign Mines Development Co. introduced motor trucks to convey its product from Borax Lake to Searles, and the Russell Borate Co. instituted animal haulage from its workings in Ventura County to Bakersfield.

*Italy.*—The entire output of crude boracic material comes from the fumarole deposits in the provinces of Pisa and Grosseto. Twelve operators, employing 442 workmen, in 1911 produced 2648 metric tons of crude material valued at $201,248, as against 2502 tons, worth $180,144 in 1910. The output of refined products in 1911 included 444 metric tons of boracic acid, worth $46,155, and 738 tons of borax, worth $57,580. The factories are all in the province of Pisa. The exports of Italy in 1911 included 902 tons of crude boracic material, 381 tons of refined boracic acid, and 63 tons of borax. Imports included 113 tons of boracic acid, and 628 tons of borax.

*Turkey.*—The latest official returns state that in 1908 the output of raw boracite was 13,714 tons, worth £89,181, and in 1909 it was 11,221 tons, worth £76,000. This is an important part of the world's output.

SOME OF THE PRINCIPAL SUPPLIES OF BORAX MATERIALS.
(In metric tons.)

| Year. | Chile. (a) | Germany. (b) | Italy. | | | United States. (c) | Total. (d) |
|---|---|---|---|---|---|---|---|
| | | | Borax Refined. | Boric Acid. | | | |
| | | | | Crude. | Refined. | | |
| 1899 | 14,951 | 183 | 709 | 2,674 | 129 | 18,466 | 37,112 |
| 1900 | 13,177 | 232 | 858 | 2,491 | 283 | 23,437 | 40,478 |
| 1901 | 11,457 | 184 | 544 | 2,558 | 347 | 6,550 | 21,640 |
| 1902 | 14,327 | 196 | ..... | 2,763 | ..... | 15,512 | 32,798 |
| 1903 | 16,879 | 159 | ..... | 2,583 | ..... | 31,232 | 50,853 |
| 1904 | 16,733 | 135 | 569 | 2,624 | 314 | 41,407 | 61,782 |
| 1905 | 19,612 | 183 | (e)1,007 | 2,700 | (e)749 | 42,036 | 64,531 |
| 1906 | 28,996 | 161 | 1,062 | 2,561 | 562 | 52,774 | 86,116 |
| 1907 | 28,374 | 114 | 881 | 2,305 | 466 | 48,444 | 80,584 |
| 1908 | 35,039 | 128 | (e)1,024 | 2,520 | (e)429 | 20,140 | 57,827 |
| 1909 | 32,218 | 149 | (e)1,110 | 2,431 | (e)578 | 15,083 | 51,569 |
| 1910 | ? | 167 | (e) 912 | 2,502 | (e)695 | 33,574 | ? |
| 1911 | ..... | 160 | (e) 738 | 2,648 | (e)444 | 51,751 | ..... |

(a) Prior to 1903, figures are for borate of lime exports. (b) Boracite. (c) Crude borax. (d) The total falls short of the world's supply, particularly because it fails to include the important production of Turkey. (e) Obtained by treating a part of the crude boric acid reported for the same year.

# BROMINE AND IODINE

The bromine production in the United States is as in recent years congested, and new uses are desired as an outlet for this element. The production is connected with the salt industry where bromine in the form of bromides is a by-product, and it is in the hands of a few large plants. The production in the following table is estimated from reliable sources, although the producers naturally do not disclose their production.

PRODUCTION OF BROMINE IN THE UNITED STATES.
(In pounds.)

| Year. | Michigan. (a) | Ohio and Penn. | West Virginia. | Total. (a) | Metric Tons. | Value. | |
|---|---|---|---|---|---|---|---|
| | | | | | | Total. | Per lb. |
| 1899 | 138,272 | 193,518 | 101,213 | 433,003 | 196 | 125,571 | 29 |
| 1900 | 210,400 | 196,774 | 114,270 | 521,444 | 237 | 140,790 | 27 |
| 1901 | 217,995 | 227,062 | 106,986 | 552,043 | 250 | 154,572 | 28 |
| 1902 | 226,452 | 194,086 | 93,375 | 513,913 | 233 | 128,742 | 25 |
| 1903 | 320,000 | 180,000 | 97,000 | 597,000 | 271 | 170,145 | 28½ |
| 1904 | 646,249 | 147,807 | 85,256 | 879,312 | 399 | 215,431 | 24½ |
| 1905 | 579,434 | 223,000 | 97,000 | 899,434 | 408 | 139,492 | 15½ |
| 1906 | 955,000 | 203,000 | 71,000 | 1,229,000 | 553 | 184,350 | 15 |
| 1907 | (b) | (b) | (b) | 1,062,000 | 482 | 138,060 | 13 |
| 1908 | (b) | (b) | (b) | 1,149,000 | 521 | 103,410 | 9 |
| 1909 | (b) | (b) | (b) | 1,100,000 | 500 | 110,000 | 10 |
| 1910 (c) | 641,300 | 155,000 | 54,000 | 850,300 | 386 | 110,539 | 13 |
| 1911 | 648,000 | 164,000 | 89,000 | 901,000 | ..... | 180,000 | 20 |
| 1912 | 840,000 | 177,000 | 68,000 | 1,085,000 | 435 | 270,000 | 25 |

(a) Includes the bromine equivalent of the bromides produced directly. (b) Not reported separately. (c) From *Eng. and Min. Journ.*

The Michigan production which is the largest, is practically all from the Dow Chemical Company, and in the form of bromide. It is estimated in 1912 at 1,020,000 lb. The uses of this production may be classified as follows: For metallurgical use probably 166,500 lb.; for the arts, 170,500 lb.; for medicinal use 683,000 lb. Of the quantity assigned to the arts probably 5000 lb. was exported to Canada; the metallurgical salts were mostly exported to Australia, 140,000 lb. and the balance to Colorado and Nevada mines. The medicinal bromide was divided about as follows: 73 per cent. was potassium bromide, 15 per cent. sodium bromide and 12 per cent. ammonium bromide. All of these were consumed in Canada and the United States, excepting some small shipments to Japan and England, not more than 5000 lb. together. The Pennsylvania production of bromine is as heretofore, from the John A. Beck Salt Company, and goes to the Hayden Chemical Company of New York.

The Dow Chemical Company in addition to the Michigan production of bromide stated, purchased the output of bromine from the following firms: Buckey Salt Co., The Excelsior Salt Co.; J. Q. Dickinson & Co. and part of the output of the Liverpool Salt Company. The purchaser therefore prevented quantities of bromine from being exported to foreign competitors manufacturing bromides. As much of this bromine was resold as liquid bromine, it has no direct effect on the production of bromides in the United States.

The great use of bromide which is expanding, is for photographic purposes. The increased moving picture business and the Kodak Company, are large consumers. The quantity assigned to the arts, is practically all consumed in this way. The stocks on hand are usually small excepting those belonging to a large producer, and may be estimated at about 500,000 lb. at all times. In purifying bromine for chemical and pharmacy use, the price is higher than the average on account of the extra process and the loss of bromine. In 1906 the purity was defined by law. A crude bromine usually contains 94 per cent. Br. Practically no bromine is imported into the United States. Germany and Great Britain both export bromine.

## Iodine

Iodine is produced principally from the mother liquor from the Chilean niter works. No iodine is manufactured in the United States, although there are possible sources of iodides from sea-weeds. Such an industry is the source of iodine salts from Norway and Japan. In the United States the sea-weeds to be treated commercially for potash, on the California coast do not promise to yield much iodine.

In the Chilean mother liquors, the iodate exists in the proportion of 0.6 per liter. Nothing new has developed in the iodine industry in recent years. Processes used twenty years ago, are the same to-day and no changes or improvements are likely. The iodine industry is the strongest kind of a "Trust," and prices are maintained at the highest point. No new installations or competition are contemplated or desired. The production is maintained of a steady output, and not even a search for new uses for the products is made. The possibilities of increasing the output from a large number of establishments, would be an easy matter if it were not for the control of the syndicate. Every existing nitrate establishment could make iodides. The total production of Chile in 1910, amounted to 1,279,150 lb.

The iodine imports into the United States are given in the following lo-

| Year. | Crude. | | Resublimed. | |
|---|---|---|---|---|
| | Pounds. | Value. | Pounds. | Value. |
| 1908 | 175,929 | $342,777 | 5 | $15 |
| 1909 | 12,910 | 25,705 | 51 | 110 |
| 1910 | 771,083 | 1,051,036 | 7 | 24 |
| 1911 | 423,353 | 841,559 | 55 | 181 |
| 1912 | 379,311 | 737,109 | 40 | 96 |

Crude iodine is imported free of duty. It is used for the manufacture of iodoform, and hydroiodate, and iodate of potash.

The potassium iodide and hydriodate imported into the United States during the fiscal years ending June 30th, were as follows:

| | Pounds. | Dollars. |
|---|---|---|
| 1908 | 2,477 | 610 |
| 1909 | 251 | 508 |
| 1910 | 142 | 275 |
| 1911 | 272 | 519 |
| 1912 | 238 | 451 |

The imports of iodine into Germany, which is the largest consumer, during 1911 amounted to 302,900 kilos, of which 235,600 came from Chile; 2200 from Peru; 1480 from Norway, and 760 from Japan. In 1912 the imports of Germany were 260,000 kg. The exports of iodine were 72,700 kg. in 1911, and 79,000 kg. in 1912. In Norway the value received for the seaweed ashes is 50 cents per ton.

# CADMIUM

The production of cadmium in the United States is estimated about the same as in 1911, in which year the output had increased five-fold. In addition, the usual production of cadmium sulphide or cadmium yellow, was maintained. In the United States only two smelteries produce cadmium as a by-product; other smelteries are contemplating the recovery of cadmium although the market is very limited. The principal production in the world comes from Upper Silesia, Germany, where in 1912 the production as stated by Paul Speier, of Breslau, was 42,757 kg. This is the only production in Germany. The cadmium sulphide produced in Germany cannot be estimated on account of a large number of small producers.

Many possible sources of cadmium in the lead and zinc smelting works are available, as the zinc ores invariably contain cadmium. The oxidized zinc ores of Leadville, showed a cadmium contents, and the sulphides contain even larger quantities. Cadmium if recovered in all cases would, of course, exceed many times the prospective market. The uses of the metal are not increasing, and the price in late years would appear to be steady. The import price is somewhat less than the domestic quotations at Cleveland. The production of Germany in kilograms is given in the table at the end of this volume. The prices in Germany have ranged between 84 and 43 cents in recent years. In 1911 the value was stated at the works as 57 cents per pound. The following table shows the imports of cadmium during fiscal years:

| | Pounds. | Dollars. |
|---|---|---|
| 1908 | ..... | 2,166 |
| 1909 | ..... | 4,643 |
| 1910 | 3,083 | 1,657 |
| 1911 | 5,956 | 3,718 |
| 1912 | 6,396 | 4,603 |

The imports of cadmium during the calendar year 1912 were 5250 lb. valued at $3764, and in 1911, 5367 lb. valued at $3870.

Cadmium is not desirable in the zinc products and must, therefore,
ıted. In Germany the usual process is fractional distillation of
In addition it is also recovered from zinc solutions obtained
facture of lithopone, and by means of zinc-dust precipitation

and electrolytic deposition. An outline of the process is given by Mr. D. M. Liddell, Vol. XIX, MINERAL INDUSTRY, p. 92.

In the mercury vapor lamps in order to whiten the light obtained in the quartz tube, a number of methods have been tried. Cadmium has been selected as the most suitable as it gives a homogeneous vapor. The vaporizing point is about 450° C., and the melting point in air about 320° C. The red line of cadmium vapor neutralizes the color of the mercury vapor. Experimental results for this use are encouraging.

# CHALK

No crude deposits of chalk exist in the United States. The consumption of whiting and Paris white is about 100,000 tons annually. The import duty of these products is 1/4 cent per pound. Very little manufactured material is imported into the United States at the present time. The following table shows the imports for fiscal years:

| | English Cliffstone. | | Ground Chalk. | | Dry Whiting and Paris White, Pounds. | Dollars. | Whiting in Oil. | |
|---|---|---|---|---|---|---|---|---|
| | Tons. | Dollars. | Pounds. | Dollars. | | | Pounds. | Dollars. |
| 1908..... | 6,752 | 11,381 | 709,967 | 22,526 | 2,399,083 | 11,467 | 132 | 6 |
| 1909..... | 10,767 | 16,437 | 1,363,005 | 32,225 | 2,089,981 | 13,540 | 76 | 7 |
| 1910..... | 8,618 | 12,260 | 2,728,382 | 69,203 | 2,868,239 | 16,305 | 17,995 | 220 |
| 1911..... | ..... | ..... | 3,826,118 | 92,423 | 4,656,958 | 18,758 | 77,581 | 1,151 |
| 1912..... | 8,522 | 11,167 | 3,809,841 | 88,391 | 3,729,155 | 14,578 | 29,047 | 866 |

It requires from 2700 to 2800 lb. of crude chalk to make 2000 lb. of Paris white or whiting. The margin of profit to the American manufacturers is small. The European manufacturer pays from $4.50 to $5.50 less per ton for both chalk and labor than does the American.

The increase in ocean freights caused advancing prices in the domestic market in 1912. The selling price of English chalk varies from $2.70 to $3 per ton; of French chalk from $2.90 to $3.35 per ton. During the latter part of the year sellers were quoting $4 to $4.25 for English, and $4.25 to $4.60 for French. The rates with charters were 12s. 6d. The consumption of chalk was mostly on contract orders by the whiting manufacturers.

American manufacturers are Southwark Manufacturing Co., Camden, N. J.; Acme White Lead & Color Works, Boston; H. F. Taintor Mfg. Company, N. Y.; G. W. MacKenzie, Phila.; Benjamin Moore & Co., Brooklyn; Stickney, Tirrell & Co., Boston.

Cliffstone Paris white[1] is sold in lump or pulverized and is largely used in potteries for making the white glaze with zinc oxide. It is used for mixing with fine grades of paint, and in making plate printing inks. The material is free from grit because it is washed and floated. In treatment the crude lump chalk is broken into small pieces, washed to settle

icles, and the fine material is then dried on steam drying pans.

from this process are disintegrated, being ground with

[1] *Oil and Drug Rep.*, March 31, 1913.

water. The average English cliffstone white, shows 1/4 per cent. silica, while the American contains as much as 2 per cent.

Common whiting is obtained by powdering the crude chalk, without washing or floating. This material on the market shows as much as 12 per cent. silica.

For fine grades whiting is sifted and used in the making of gilders and Spanish whiting. In the making of putty for which no edge runner mill should be used, 85 lb. of whiting and 15 lb. of linseed oil are required. The better putty usually specified consists of 75 lb. of whiting, 8 lb. of dry white lead and 14 lb. of raw linseed oil. Much of the putty that is on the market has not been made from whiting, and is adulterated by marble dust, etc. The weight of dry whiting averages 8 to 9 lb. per gallon. It is used in paints, especially with red lead and oil, when it prevents running. It does not do well with pigments in oil that must be thinned with varnish.

*Other Countries.*—The United Kingdom produces annually about 4,500,000 tons of chalk. In 1911 the production was 4,884,020 tons, valued at £199,573.

It is reported that a whiting plant in Mexico, Campeche, produces a grade of product closely resembling the English chalk.[1]

Germany imported, in 1911, 34,828 tons of washed chalk, valued at $261,800, exported about 10,000 tons, mostly to Austria. Half of the imports came from France, and about one-fourth each from Belgium and Sweden. The production of Bavaria in 1911 amounted to 21,287 tons, valued at 362,282 marks. According to Consul William F. Doty, the imports of chalk at Riga, Russia, were 92,000 long tons in 1910, and 87,487 long tons in 1911. Australia imports chalk from the United Kingdom and from Germany. In 1910, 4000 tons were imported from the United Kingdom, valued at $28,868, and 250 tons from Germany.

[1] Dly. Consls. and Tr. Rep., April 7, 1913.

# CHROMIUM

The only production of chromite in the United States in 1912, was from California. Deposits of chromic iron ore exist in the United States in Pennsylvania, Maryland, North Carolina, Wyoming, and on the Pacific coast.

The chrome ore produced in 1912 amounted to 1220 tons, valued at $10,310, as compared with 935 tons, valued at $14,197, in 1911. These figures are from the report of the State mineralogist of California, and the decrease in value was due to an inferior grade of ore. The output came from Shasta and Siskiyou Counties. The available ore in California largely exceeds the local demand, which is mostly for refractory material in reverberatory and other furnace linings. The low price of the material and its limited consumption, together with its disseminated nature, makes cheap production and transportation essential.

The imports of chrome ore are increasing from year to year, although there is a tendency to include lower grade ores which come into direct competition with the domestic ores. The domestic ores are used in the form of either lump or grains chiefly for furnace-linings and as these last a long time the domestic product is sufficient to supply the small demand. The foreign ores are used chiefly in the manufacture of chemicals; no ferro-chrome is made in the United States on a commercial scale. Chemicals containing chromium are also imported directly. The following tables show the production and imports to the United States and the principal sources of chrome ore in foreign countries:

STATISTICS OF CHROME ORE IN THE UNITED STATES.
(In tons of 2240 lb.)

| Year | Production. (a) | | | Imports. | | | Consumption. | |
|---|---|---|---|---|---|---|---|---|
| | Long Tons. | Value. | Value per ton. | Long Tons. | Value. | Value, per Ton. | Long Tons. | Value. |
| 1899..... | *Nil.* | ..... | ..... | 15,793 | $ 284,825 | $18.03 | 15,793 | $284,825 |
| 1900..... | 140 | $1,400 | $10.00 | 17,542 | 305,001 | 17.39 | 17,682 | 306,401 |
| 1901..... | 130 | 1,950 | 15.00 | 20,112 | 363,108 | 18.05 | 20,242 | 365,058 |
| 1902..... | 315 | 4,725 | 15.00 | 39,570 | 582,597 | 14.73 | 39,885 | 587,322 |
| 1903..... | 150 | 2,250 | 15.00 | 22,931 | 302,025 | 13.13 | 23,081 | 304,275 |
| 1904..... | 123 | 1,845 | 15.00 | 24,227 | 348,527 | 14.38 | 24,350 | 350,372 |
| 1905..... | 40 | 600 | 15.00 | 54,434 | 725,301 | 13.32 | 54,874 | 725,901 |
| 1906..... | 317 | 2,859 | 9.00 | 43,441 | 557,594 | 12.84 | 43,758 | 560,453 |
| ..... | 335 | 5,620 | 20.00 | 41,999 | 491,925 | 11.71 | 42,333 | 498,605 |
| | 280 | 5,600 | 20.00 | 27,876 | 345,960 | 12.40 | 28,156 | 351,560 |
| | (b)598 | 8,300 | 13.88 | 39,820 | 460,758 | 11.57 | 40,418 | 469,058 |
| | 450 | 6,075 | 13.50 | 38,579 | 415,768 | 10.77 | 39,029 | 421,843 |
| | 935 | 14,197 | 15.20 | 37,529 | 407,958 | 10.85 | 38,464 | 422,155 |
| | 220 | 10,310 | 8.45 | 53,929 | 499,818 | 9.30 | 55,149 | 510,128 |

y the California State Mining Bureau except for 1907, 1908 and 1910, for which e compiled from our own reports. (b) U. S. Geological Survey.

THE PRINCIPAL SUPPLIES OF CHROME ORE. (*a*)
(In metric tons.)

| | 1902 | 1903 | 1904 | 1905 | 1906 | 1907 | 1908 | 1909 | 1910 | 1911 | 1912 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bosnia | 270 | 147 | 279 | 186 | 320 | 310 | 500 | 310 | 320 | 250 | 200 |
| Canada | 817 | 3,184 | 5,512 | 7,781 | 7,936 | 6,528 | 6,554 | 2,470 | 279 | 200 | ..... |
| Greece | 11,680 | 8,478 | 15,430 | 8,900 | 11,530 | 11,730 | 4,350 | 9,600 | 7,000 | 4,615 | ..... |
| India | .... | 260 | 3,654 | 2,751 | 4,445 | 18,597 | 4,821 | 9,398 | 1,765 | 3,864 | 2,936 |
| New Caledonia (*b*) | 10,281 | 21,437 | 42,197 | 51,374 | 57,367 | 25,371 | 46,890 | 40,000 | 40,000 | 82,806 | 51,516 |
| New South Wales | 454 | 1,982 | 403 | 53 | 15 | 30 | *Nil.* | *Nil.* | *Nil.* | 150 | 23 |
| Rhodesia | .... | .... | .... | .... | 3,308 | 7,273 | 12,118 | 37,024 | 40,000 | 47,600 | 62,850 |
| Russia | 19,655 | 16,421 | 26,575 | 27,051 | 16,969 | 25,528 | 10,950 | (*c*) | (*c*) | (*c*) | (*c*) |
| United States | 320 | 152 | 125 | 40 | 322 | 339 | 284 | 606 | 456 | 949 | 1240 |

(*a*) From the official reports of the respective countries. No complete statistics are available for Turkey or Africa. (*b*) Exports, except 1909 and 1910. (*c*) Statistics not yet available.

Pure chromite contains 68 per cent. chromic oxide, the balance being ferrous oxide, but as most ores contain other minerals, the mined product seldom runs much more than 50 per cent. In some ores the iron and alumina in other minerals prevents concentration to obtain a high-grade product. Low-grade material can, however, be utilized for chemical purposes and some new processes are said to be commercially profitable on lower grade ores in Sweden. The table gives some typical analyses.

COMPOSITION OF CHROMIUM ORES.[1]

| | Chromium Sesquioxide $Cr_2O_3$ | Ferrous Oxide FeO | Alumina $Al_2O_3$ | Silica $SiO_2$ | Magnesia MgO | Lime CaO. |
|---|---|---|---|---|---|---|
| | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. | Per ct. |
| *United Kingdom*, Shetland Islands | 42.20 | 24.93 | 7.47 | 6.10 | 17.30 | .... |
| *Hungary*, Orsova | 38.95 | 16.13 | 17.50 | 8.00 | 17.20 | 2.20 |
| *Norway*, Drontheim | 42.00 | 19.72 | 12.00 | 5.00 | 21.38 | .... |
| *Russia*, Urals | 55.75 | 21.56 | 3.37 | 5.37 | 13.85 | 0.60 |
| Ekaterinburg | 49.49 | 23.27 | 6.77 | 7.07 | 13.40 | .... |
| Orenburg | 53.00 | 24.92 | 8.05 | 3.05 | 10.98 | .... |
| *Asia Minor*, Broussa | 56.80 | 12.06 | 14.00 | 1.45 | 15.00 | 0.70 |
| | 60.14 | 15.70 | 6.34 | 1.08 | 16.40 | .... |
| *Ceylon*, Bambarabotuwa Dist. | | | | | | |
| Central Provinces | 46.58 | 19.90 | 2.86 | trace | 5.63 | .... |
| *British North Borneo*, Malliwalli Island | 51.21 | 18.90 | 9.58 | 1.04 | 16.46 | .... |
| *United States*, | | | | | | |
| Shasta Co., California | 42.45 | 15.00 | 16.75 | 7.50 | 16.50 | 0.90 |
| San Luis Obispo Co., California | | | | | | |
| (crude ore) | 43.70 | 14.00 | 15.96 | 7.96 | 16.49 | 0.66 |
| (concentrate) | 52.86 | 15.45 | 11.59 | 3.00 | 16.26 | 0.76 |
| North Carolina, Corundum Hill | 57.20 | 25.68 | 7.82 | 2.80 | 5.22 | .... |
| Pennsylvania, Chester | 41.55 | 62.02 | ..... | 1.25 | ..... | .... |
| *Canada*, Coleraine (crude ore) | 45.95 | 22.50 | 8.90 | 7.68 | 4.90 | 0.12 |
| Black Lake (concentrate) | 50.35 | 17.77 | 9.90 | 3.10 | 16.02 | 1.80 |
| Bolton | 45.90 | 35.68 | 3.20 | ..... | 15.03 | .... |
| *Newfoundland*, Port-au-Port Bay | 49.23 | 17.21 | 7.50 | 6.51 | 18.66 | .... |
| *Africa*, Transvaal | 37.03 | 23.95 | 17.23 | 7.63 | 9.94 | 2.00 |
| Rhodesia | 46.36 | 18.66 | 13.18 | 4.58 | 13.64 | .... |
| *New Caledonia* (cargo sample) | 54.50 | 17.70 | 11.00 | 3.10 | 8.00 | 1.50 |

[1] Imperial Institute, Vol. VIII, No. 4.

The chemical compounds of chromium in the market, are the pigments such as chrome green, Guignet's green, chrome yellow, chrome

orange and chrome red. Of these chrome yellow, chrome orange and chrome green are used as dyes. Chromium salts, including chromates and bi-chromates are used in the dyeing and printing of cotton, linen and wool. The chromic oxide reduced, is fixed in the fiber. In tanning white leathers chromium salts are used, making the leather resistant to moisture. Metallic chromium and alloys are produced only experimentally in the United States. Ferro-chrome enters into the manufacture of certain steel, as in armor-piercing shot and armor plate.

The imports of ferro-chrome and chromium during the calendar year 1912, were 436 tons valued at $47,179, dutiable at 25 per cent. and 38 tons valued at $26,520 dutiable at 20 per cent. Much of this material comes from France. The regulation of prices of ferre-chrome was effectively maintained in 1912 by an international ferro-chrome syndicate,[1] which embraces all important European producers. Americans are not included, for the reasons stated that the American output is absorbed locally, and the tariff for importation into the United States is prohibitive.

The import trade in chrome yellow or green, is shown by the imports for the fiscal years ending June 30 , in the following table:[2]

| | Pounds. | Value. |
|---|---|---|
| 1912 | 161,153 | $24,731 |
| 1911 | 156,733 | 25,516 |
| 1910 | 156,586 | 25,029 |
| 1909 | 170,073 | 23,107 |
| 1908 | 109,494 | 19,492 |

The chrome colors exported from Germany in 1911 were 2566 tons valued at $432,922. Netherlands, Belgium and Great Britain are the principal consumers.

The chromium chemicals exported from Rhenish Prussia to the United States in 1912 were valued at $7445.

CHROMATE AND BICHROMATE OF POTASH, CHROMIC ACID, AND CHROME ORE IMPORTED AND ENTERED FOR CONSUMPTION IN THE UFITED STATES, 1907 TO 1912, INCLUSIVE.

| Year. | Chromate and Bichromate of Potash. | | Chromic Acid. | | Chrome Ore. | | Total Value. |
|---|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | |
| | Pounds. | | Pounds. | | Long Tons. | | |
| 1907 | 18,171 | $1,307 | 1,834 | $403 | 41,989 | $491,925 | $493,635 |
| 1908 | 216,081 | 15,453 | 3,805 | 708 | 27,876 | 345,960 | 362,121 |
| 1909 | 537,017 | 28,837 | 7,559 | 1,412 | 39,624 | 460,758 | 491,007 |
| 1910 | 406,790 | 19,569 | 9,850 | 1,635 | 38,579 | 415,768 | 436,972 |
| 1911 | 22,408 | 2,159 | 6,789 | 1,349 | 37,540 | 407,958 | 411,466 |
| 1912 | 32,913 | 3,085 | 8,728 | 1,376 | 53,929 | 499,818 | $504,279 |

From the table of the imports of chromate and chromic acid into the United States, it is apparent that these imports in recent years are on a

[1] *Min. Journ.*, Nov. 2, 1912.
*il, Paint and Drug Reporter.*

decline. The imports of crude ore on the contrary are increasing. Chromate and bi-chromate during 1912 was dutiable at 2 1/4 cents per pound, and chromic-acid at 2 cents per pound.

## Foreign Countries

*Chromiferous Iron Ores.*—The occurrence of these ores containing a low percentage of chromium is well known and the localities are Canada, Cuba, Greece and Tasmania. The chrome ores of Canada occur in both fresh and decomposed peridotite.[1]

The principal deposits are the Mayari, Moa, Cubitas, Taco Bay, and Navas. The ore reserves are estimated at 1,000,000,000 tons. The Cuban ores are residuals or laterites in serpentine.[2]

The ores in Greece are not as clay-like as those of Cuba, and appear to be the result of lateral secretion. This applies to both the chromium and nickel ores which are associated. The deposits of Greece[3] have made shipments to the end of 1912, amounting to 1,930,000 tons chiefly from Lokris, Thebes and Tsouka. A feature of the ores, is their uniform composition. A typical analysis is as follows: Iron 46 per cent., alumina 14 per cent., silica 8 per cent., chromium 2.5 per cent., nickel and cobalt 0.6 per cent., phosphorus 0.02 per cent., and sulphur 0.03 per cent. A typical analysis of the ore from Cuba is as follows: Iron 42 to 46 per cent., alumina 3 to 13 per cent., silica 1.5 to 5 per cent., chromium 1.7 to 6 per cent., nickel and cobalt 0.3 to 1.3 per cent., phosphorous 0.015 to 0.03 per cent. The product is nodulized giving nodules of the following composition: Iron 54 per cent., silica 3.6 per cent., alumina 13.8 per cent., manganese 0.8 per cent., sulphur 0.04 per cent., nickel 0.9 per cent., chromium 2 per cent., phosphorous 0.016 per cent., moisture 1.9 per cent. While the fuel consumption in smelting this ore was found in Pennsylvania to be greater than for Lake Superior ores, there is no difficulty in the smelting, and the iron produced has excellent properties. The occurrence of chromiferous ore in Tasmania, is at Ironstone Hills, near the Tamar river at Port Lampier. The ore is associated with serpentine and sandstone. An analysis is as follows: $Fe_2O_3$ 80 per cent., $Al_2O_3$ 5.8 per cent., $SiO_2$ 4.8 per cent., $Cr_2O_3$ 3.4 per cent. (Cr 2.3 per cent.), $H_2O$ 5.1 per cent. A feature of this ore, is the low sulphur and phosphorus contents. The pig-iron smelted by an early company, contained as high as 6 per cent. chromium and was found unsatisfactory.

The chief foreign producers of chrome ore, are New Caledonia,

[1] H. L. Strangeways, Chromic Iron Mining and Milling in Canada, *Can. S. C. E.*, Nov. 21, 1907.
[2] C. M. R. Welld, *A. I. M. E.*, 1909.
[3] M. Scott, Congress of the Iron and Steel Institute, 1913.

Rhodesia, Asia Minor, Russia, Greece and India. Chrome ore exported from Australia in 1912, was 453 cwt. valued £60.

*Africa.*—Some notes and analyses of chrome ore found in the Transvaal and in Natal, are given in MINERAL INDUSTRY, Vol. XX, p. 126.

The chromite deposits of Sekukuniland, are numerous and extensive. They extend from near the junction of the Malips and Olifants Rivers, southeastward at least as far as the Steelpoort River. Three separate reefs are exposed in one cut. The deposits are bedded and vary in thickness from 1 to 4 ft. An analysis of the ore gave: Chromium sesquioxide 51.29 per cent., ferrous oxide 23.33 per cent., manganous oxide 0.60 per cent., alumina 2.40 per cent., cobalt and nickel oxides 0.40 per cent., lime 1.12 per cent., magnesia 4.32 per cent., silica 4.40 per cent., water 12.10 per cent., phosphorus and sulphur, traces; platinum, absent. This ore is much richer than the other occurrences both in eastern and central Transvaal, these latter rarely showing more than 40 per cent. of chromium sesquioxide. In Rhodesia the important deposit at Selukwe is being actively worked as in previous years. The only exports from Portuguese East African ports of large amount, to the United States, is chrome ore. This ore is shipped to Beira 560 miles by railroad from the mines in Rhodesia. In 1912, the ore exported by way of Beira is reported as 61,548 tons as compared with 38,183 tons in 1911, and 37,235 tons in 1910. The United States is credited of these totals, with 32,500 tons in 1912, 9600 tons in 1911, and 18,800 tons in 1910. In the year 1911 it is highly probable that a considerable amount of the 28,583 tons credited to European ports was trans-shipped to the United States. It is understood that 18,229 tons in that year were carried by the Deutsche Ost Afrika Linie, with headquarters at Hamburg. This company purchased the ore for the sake of freight, the mines having a carrying contract with the Union Castle Co., a rival line. The value of the chrome ore exported in 1911, was $489,730, and the portion to the United States was valued at $208,000.[2] The production officially reported by the Rhodesia Chamber of Mines, was 69,260 short tons of chrome-ore. The total chrome iron ore produced in Rhodesia up to and including 1912, was 216,268 tons valued at £497,984. The Rhodesia Chrome Mines Limited paid a dividend of 10 per cent. in 1911. The exports reported by the company were 53,363 tons in 1911, as compared with 44,002 tons in 1910.

*Canada.*—Practically all the production comes from Eastern Quebec. The normal output is 6000 to 8000 tons. The production in 1911 is valued at $2587, being 157 short tons. The production in 1910 was

[1] A. L. Hall, Union of South Africa Mines Dept., *Geol. Surv.*, 1911.
[2] Daily Consl. and Trd. Rep., Nov. 2, 1912.

299 tons valued at $3734. The exports for the same year, are reported as only 15 tons valued at $150.

*Greece.*—The chromite produced in Greece in 1910, was 7000 metric tons, containing 39 per cent. chromic-acid; 9450 tons were sold in this year at 400,660 francs. The stocks on hand at the beginning of 1911, were 2550 tons. The chromiferous ores of Northern Greece and Islands of Eubea and Spyros, are described under "Chromiferous Iron Ores." The chromite mined in Greece comes from Pharsala.

The chrome ore exported to the United States from Greece, and declared at Consular offices, was valued $96,668 in 1910 and $2250 in 1911.

*India.*—A marked improvement in the output from Baluchistan, was reported for the year 1911. The industry reached its highest point in 1907, and in the following year a rapid decline took place in the output. In 1910 the industry was completely extinguished in Mysore, but it declined also in Baluchistan. The output in 1910, was 1737 tons valued at £2315; in 1911 it was 3804 tons valued at £5072. The production in 1909 was 9250 tons. The localities in Baluchistan are chiefly in Quetta-Pishin and Zhob districts, where the ore occurs in masses of serpentine.

*Japan.*—The chrome ore produced in Japan in 1911 amounted to 1527 metric tons.

*New Caledonia.*[1]—The chromium ore exported in 1911, from New Caledonia, was 82,806 tons; in 1912, 51,516 tons. The average value of chrome ore has gradually fallen from 50 francs in 1900, per ton f.o.b., to 25 francs in 1910. Since this latter period it has gradually risen, due to the Chrome Company which controls the sales of both New Caledonia and South Africa.

The chromium ore of New Caledonia is much in favor in the market. The Tiebaghi Co. has succeeded in obtaining an outlet which is expected to be permanent, for the sale of the New Caledonia ore.

The Société le Chrome, intends to utilize its hydroelectric plant under construction on the Bay of Yate, (15,000 h.p.), for the manufacture of ferro-chrome and also ferro-nickel.

*Newfoundland.*—The only deposits of chromite in Newfoundland are those at Buff Head on the north side of Port-au-Port Bay on the western coast. These deposits are in diorite which is traversed by thick beds of serpentine. While some ore has been shipped as mined, a large body of low-grade concentrating material is known to exist and has been prospected. A mill is erected on the ground. It has been demonstrated that 55 per cent. concentrates can be readily produced. Transporta-

[1] G. du Poizat, *Echo Des Mines*, April 10, 1913.

tion facilities are good, and a large tonnage can be placed in sight with little expense. The property has not been worked for several years.

*Turkey.*—Germany and France derived some of the chromite imported from Mersina. The ore runs to 51 per cent. chromic-oxide. References to the deposits in Turkey, were made in MINERAL INDUSTRY, Volume XX, p. 129, and in the Mineral Resources of the United States Geological Survey, 1911, p. 983. Chrome ore exports from Turkey to the United States, were valued at $35,014 in 1910, and $46,993 in 1911. The last official report of the Department of Mines and Forests of Turkey is for the fiscal year ending March, 1909. In 1908, 28,860 metric tons were produced valued at £90,470; in 1909, 11,546 metric tons valued at £31,000.

## THE METALLURGY OF CHROMIUM

BY G. A. ROUSH

The metallurgy of chromium, while making no great strides during 1912, has shown some rather interesting developments along several lines, particularly in the field of alloys.

Some time ago Haynes[1] described the production of alloys of cobalt and chromium, having hardness and tensile properties comparable with steel. This alloy was suggested as a substitute for steel in cutlery. In a recent article[2] more recent experiments with these alloys are described. The addition of tungsten and molybdenum to the cobalt-chromium alloy gives alloys comparable with high-speed steels. Holding the chromium at 15 per cent. and varying the proportions of cobalt and tungsten, the hardness of the alloy increases with the tungsten content. After passing 25 per cent. tungsten, the alloy is too hard to forge readily, but can be cast into bars, and after grinding to proper shape, can be used as high-duty cutting tools *in the cast condition.* A 40 per cent. alloy works still better. In like manner the hardness increased with the addition of molybdenum. With 25 per cent. molybdenum a hard, fine-grained metal results, which takes a good cutting edge, has a fine color and luster, and promises a wide application for fine cutlery.

S. W. Parr[3] describes an alloy of chromium that is almost free from corrosion by the ordinary acids. As first produced, the alloy was a combination of chromium, copper and nickel, and showed the following relative solubility in 25 per cent. nitric acid in 24 hours, using test pieces of approximately the same superficial area.

[1] *Journ. Indus. Eng. Chem.*, II, 397 (1910).
[2] *Eighth Intl. Cong. Appl. Chem.*, XXI, 19, (1912); *Met. Chem. Eng.*, X, 804 (1912).
[3] *Eighth Intl. Cong. Appl. Chem.*, II, 209.

| | |
|---|---|
| Pure iron (99.8 per cent.) | 100.0 per cent. dissolved. |
| Commercial aluminum | 51.4 |
| Monel metal | 19.2 |
| (Ni 90, Cr 10) | 7.9 |
| (Cu 90, Al 10) | 3.5 |
| (Ni 79, Cr 20, Al 1) | 1.3 |
| Ferro-silicon | 0.1 |
| (Cr 20, Cu 10, Ni 70) | 0.023 |

The addition of other metals in small quantities, partly as deoxidizers to aid in making good castings, also added slightly to the resistance to acids. Following is the average composition finally adopted:

| | |
|---|---|
| Ni | 66.6 per cent. |
| Cr | 18.0 |
| Cu | 8.5 |
| W | 3.3 |
| Al | 2.0 |
| Mn | 1.0 |
| Ti | 0.2 |
| B | 0.2 |
| Si | 0.2 |

"Nichrome" wire, a nickel-chromium alloy developed by the Driver-Harris Wire Co., has been for several years in the market as a high resistance alloy. They have recently placed on the market "Nichrome II," which has even higher electrical resistance, a smaller temperature coefficient, and also increased resistance to oxidation. The constants of this material are as follows: Resistance, 660 ohms per mil-foot; temperature coefficient, +0.00018 per degree C. The alloy is claimed to be permanent at 1100° C.

The Goldschmidt Co. have recently placed on the market a practically carbon-free ferro-chromium, of very uniform composition, carrying 75–76 per cent. chromium. This is made by the aluminothermic process, as is also their pure, carbon-free chromium. These low carbon materials are particularly useful in making low carbon chromium, chrome-nickel, and chrome-tungsten steels.

J. Naulty[1] patents the manufacture of a chromium alloy, melting copper and nickel, and any other desired metal with chromium, with the use of aluminium as a flux.

Ségny[2] patents the formation of filaments of chromium for incandescent electric lights or for mantles for incandescent gas burners. A thread of cotton is immersed in a slightly acid solution of a chromium salt and carbonized out of contact with air. The thread is then heated to incandescence in a rarefied hydrocarbon atmosphere, forming carbide of chromium, and is finally decarburized, and made conducting by heating it to a high temperature in an atmosphere of hydrogen.

E. R. Berry[3] patents the use of carbides of chromium and titanium in arc light electrodes. The method of making the carbides is not mentioned.

[1] Brit. Pat. 41, Jan. 2, 1911.
[2] Fr. Pat. 443,530, July 17, 1911.
[3] U. S. Pat. 1,017,497, Feb. 13, 1912.

Boeringer and Sōhne[1] patent the electrolytic oxidation of chromium solutions in an apparatus without a diaphragm, the liquid being conducted through or over an anode of lead shot resting on a lead support, thus forcing it to traverse a long path.

H. A. Voedisch and P. Kreismann[2] patent a process for the recovery of chromium compounds from leather scraps and offal, for reuse in tanning. The material is soaked in a bath of an alkalin hydroxid for about two weeks, washed with water for a day and then placed in a bath containing an acid (acetic, nitric, sulphuric or sulphurous) for two or three days. The acid and alkalin liquors are then mixed and the precipitated chromium salts separated by decantation and dried.

## Chromite as a Refractory

According to the experiment of C. P. Randolph,[3] chromite brick fired at 1300°, at 1200° gives a thermal resistivity of 38° C. per watt per cubic inches and it varies in other chromite bricks down to 14 units. Such bricks weigh 128 lb. per cubic foot. Chromite and clay bricks fired at 1050° (weight 144 lb. per cubic foot), at 1000° have a resistivity of 34 units and fired at 1300° (weight 155 lb. per cubic foot), at 1200° have a resistivity of 28 units. The units are degrees centigrade per watt per cubic inch. Alundum has a higher resistivity to heat, whereas carborundum has much less; fire-brick would appear to be about the same.

One brand of chromite brick was found to melt[4] at 2050° C. A sample of natural chromite from another source melted at 2180° C.

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**Chromite Deposits** of Sekukuniland, Transvaal, (*Bull. of the Imp. Inst.*, 1912, p. 331.)

"L'annee commerciale 1911. (Review of mining and metallurgy in New Caledonia in 1911.) (*Bull. du Commerce N. Caledonie*, Apr. 6, 1912, pp. 1-4.

[1] Ger. Pat. 251,694, July 9, 1911.
[2] Brit. Pat. 9,462, April 18, 1911.
[3] *General Electric Rev.*, Feb., 1913.
[4] C. W. Kanolt, *Eighth Intl. Cong. Appl. Chem.*

# COAL AND COKE

By A. T. Shurick

The year 1912 in some respects was an eventful one. It witnessed the largest suspension of organized labor the industry has ever experienced, saw the final completion of the Government suits against the alleged anthracite coal combine, the election of what promises to be one of the most radical executives the country has ever had, and yet, in spite of all these unsettled conditions, a new high record of production was established. In addition to this, the year was a prosperous one for the coal men. As a rule, higher prices prevailed which, with the heavy production, materially improved the financial condition of the operators.

By far the most important episode during the year was the joint suspension of both the anthracite and bituminous miners on Apr. 1. Approximately half a million men laid down their tools on that date and the productive capacity of the country was almost immediately restricted to 35 per cent. normal. The enormous magnitude of the trouble will be better understood by the statement of one authority who placed the daily loss during the suspension to the miners at $800,000, the value of the product at the mine, during each day these were idle, being $1,200,000. This concerted action on the part of both the hard- and soft-coal miners has made it clear that labor has learned an important lesson from syndicated capital with its interlocking directory, alliances, etc., and has now become syndicated labor. During the year determined and persistent efforts were made in West Virginia to organize the miners there, and the struggle became of such proportions as to attract a nation-wide attention and, later, an investigation by a Senatorial committee from Congress.

The production for the country established a new high record, namely about 529,500,000 short tons. This exceeds the previous high record of 1910 by about 10 per cent. The increase is entirely in bituminous coal, the anthracite production being only 75,322,855 long tons, which is 5,448,633 tons less than 1911, the decrease being entirely due to the complete suspension of mining during the fixing of the new wage scale. The new agreement providing a general increase of about 10 per cent. to the miners likewise necessitated advancing the price

of coal. As the steam grades of anthracite are in such close competition with bituminous coal, it was necessary to place the entire burden of this increase on the prepared sizes which were accordingly advanced 25 cents per ton.

PRODUCTION OF COAL IN THE UNITED STATES.
(In tons of 2000 lb.)

| Bituminous. | 1911. | | | 1912. | | |
|---|---|---|---|---|---|---|
| | Short Tons. | Values at Mines. | | Short Tons. | Values at Mines. | |
| | | Total. | Per Ton. | | Total. | Per Ton. |
| Alabama | 15,021,421 | $18,175,920 | $1.21 | (a) 16,010,600 | $20,829,252 | $1.30 |
| Arkansas | 1,200,000 | 1,896,000 | 1.58 | (b) 2,100,000 | 3,360,000 | 1.60 |
| California and Idaho | 5,000 | 17,500 | 3.50 | 14,848 | 39,092 | 2.06 |
| Colorado | 10,157,383 | 14,747,764 | 1.40 | (a) 10,977,824 | 16,453,336 | 1.48 |
| Georgia | 165,330 | 231,462 | 1.32 | 227,503 | 338,426 | 1.47 |
| Illinois | (c)49,163,710 | 53,096,807 | 1.08 | 57,685,700 | 63,453,570 | 1.10 |
| Indiana | 14,209,661 | 15,488,530 | 1.09 | (e) 14,204,578 | 15,625,036 | 1.10 |
| Iowa | 7,729,674 | 13,140,000 | 1.69 | (b) 6,900,000 | 11,730,000 | 1.70 |
| Kansas | 6,390,207 | 9,585,300 | 1.50 | 6,800,000 | 9,200,000 | 1.50 |
| Kentucky | 13,723,235 | 13,723,235 | 1.00 | 16,000,000 | 16,000,000 | 1.00 |
| Maryland | 4,666,100 | 5,399,000 | 1.16 | (a) 4,964,088 | 5,839,079 | 1.18 |
| Michigan | 1,476,074 | 2,656,900 | 1.80 | (a) 1,206,230 | 2,399,451 | 1.99 |
| Missouri | 3,760,607 | 6,581,000 | 1.75 | (b) 3,710,992 | 5,326,117 | 1.75 |
| Montana | 2,913,397 | 5,827,000 | 2.00 | (a) 3,043,495 | 5,342,168 | 1.75 |
| New Mexico | 3,148,158 | 4,816,700 | 1.53 | (a) 3,536,824 | 5,037,051 | 1.70 |
| North Dakota | 468,700 | 783,355 | 1.65 | 499,480 | 765,105 | 1.55 |
| Ohio | 30,342,039 | 31,859,140 | 1.05 | (a) 34,524,727 | 37,079,573 | 1.09 |
| Oklahoma | 3,074,242 | 6,148,500 | 2.00 | (b) 3,675,418 | 7,867,331 | 1.93 |
| Oregon | 45,000 | 79,000 | 2.75 | (b) 48,200 | 134,960 | 2.80 |
| Pennsylvania | 144,754,163 | 156,334,500 | 1.08 | (a) 161,865,488 | 169,370,497 | 1.10 |
| Tennessee | 6,451,208 | 6,773,769 | 1.05 | 6,544,000 | 6,871,220 | 1.05 |
| Utah | 2,501,472 | 4,102,500 | 1.64 | (a) 3,016,149 | 5,046,451 | 1.67 |
| Texas | (d)1,974,593 | 4,976,000 | 2.51 | (b) 2,000,000 | 5,200,000 | 2.60 |
| Virginia | 6,864,667 | 6,384,000 | 0.93 | (a) 7,846,638 | 7,518,576 | 0.69 |
| Washington | 3,550,906 | 8,877,260 | 2.50 | (b) 3,650,000 | 9,490,000 | 2.60 |
| West Virginia | 59,920,207 | 53,900,000 | 0.91 | (a) 66,786,687 | 62,792,234 | 0.94 |
| Wyoming | 6,744,900 | 10,508,900 | 1.56 | (a) 7,368,124 | 11,648,088 | 1.67 |
| Alaska | 900 | 7,200 | 4.00 | (b) 1,200 | 4,800 | 4.00 |
| Total Bituminous | 400,422,954 | $456,117,242 | ..... | 445,208,793 | 504,761,413 | ..... |
| Anthracite. | | | | | | |
| Colorado | 65,500 | 134,400 | 2.80 | 69,037 | 193,303 | 2.80 |
| New Mexico | 8,000 | 24,000 | 3.00 | 47,892 | 143,676 | 3.00 |
| Pennsylvania | 90,464,066 | 174,952,415 | 2.00 | (a)84,361,598 | 177,622,626 | 2.00 |
| Total Anthracite | 90,537,566 | $175,110,815 | 2.00 | 84,478,527 | 178,959,605 | ..... |
| Total coal | 490,887,020 | 631,069,657 | 1.28 | 529,576,381 | 682,384,039 | ..... |

(a) As reported by the U. S. Geological Survey. (b) Estimated. (c) For fiscal year ending June 30. (d) Does not include 979,232 tons lignite, valued at $941,700. (e) Fiscal year ended Sept. 30.

The Supreme Court decision in the case of the anthracite companies, rendered toward the close of the year, was of a mixed character and more or less indefinite in its findings. On the 35–65 per cent. contracts the opinion of the court below was reversed, it being held that, while these contracts, considered singly, were wholly innocent, when taken collectively they were a direct restraint of interstate commerce. As is well known, the amount handled under these contracts is only between 20

and 25 per cent. of the production, and the operators do not regard the decision with any particular alarm, although the Government claims that this will ultimately affect a complete disintegration of the anthracite working agreement. The lower court was sustained in its decision requiring the dissolution of the Temple Iron Co., which was the second important point covered. It is doubtful, however, if even the Government regarded this victory of any significance, for the reason that this concern has long since served its usefulness and at the time was only being used as a sort of round table at which the leading operators could discuss conditions. On the whole the Government failed utterly to prove the existence of any trust, although it is none the less true that such a condition really exists; but it is not in such tangible form that the present laws can be brought to bear upon it.

The coal markets during the year were, on the whole, favorable to the operators. In many respects the situation was abnormal, due to the protracted suspension in both the anthracite and bituminous fields pending the arrangement of the new wage scale. In anticipation of this condition, there was a heavy buying movement, considerable of which was on speculation. Prices became quite buoyant and as the difficulty in obtaining the desired tonnages increased, the demand became more urgent and a temporary panicky condition occurred when the suspension finally became a reality.

Consumption during midsummer, however, appeared to be at an unusually low point so that buyers again assumed control of the market, and prices eased off to a low level. Severe weather together with a pronounced car shortage, so reduced shipments toward the close of the year that the market steadied up materially and closed strong.

In transportation, one of the vital functions of the coal industry, an important decision, far-reaching in its effects, was handed down by the Interstate Commerce Commission. This was what was known as the Pittsburg Lake Rate Case; it hinged on the comparative rates from the Pittsburg and West Virginia mining districts to the Lake ports, it having been long conceded that the Pittsburg operators were seriously discriminated against in this respect. It was estimated that the tonnage affected by the decision would be in excess of 60,000,000 tons per annum.

The readjustment made by the commission established a differential in favor of the Pittsburg district of about 20 per cent.; but coincident with the time this ruling went into effect, the railroads made a general horizontal reduction on all the West Virginia rates to the Lakes, so that practically the same differential in effect before, was again established. The commission found in its ruling that the carriers had established the existing rates in order to let certain competing coal fields into the Lake

trade and this obvious attempt of the railroads to usurp the producers, rightful prerogative is a direct imposition on the industry and should be remedied.

PRODUCTION OF COKE IN THE UNITED STATES.
(In tons of 2000 lb.).

| | 1911. | | | 1912. | | |
|---|---|---|---|---|---|---|
| | Short Tons. | Value. | | Short Tons. | Value. | |
| | | Total. | Per Ton. | | Total. | Per Ton. |
| Alabama | 3,172,102 | $8,945,328 | $2.82 | (d)2,975,489 | $8,098,412 | $2.72 |
| Colorado | 946,284 | 2,876,703 | 3.04 | 972,539 | 3,014,870 | 3.10 |
| Georgia and North Carolina | 60,000 | 210,000 | 3.50 | 111,000 | 388,000 | 3.50 |
| Illinois | 675,000 | 3,037,500 | 4.50 | (d)1,764,944 | 8,069,903 | 4.57 |
| Indiana | ..... | ..... | ..... | 2,616,339 | 12,528,685 | 4.43 |
| Kansas | 10,000 | 36,000 | 3.60 | 8,000 | 28,800 | 3.60 |
| Kentucky | 75,000 | 165,000 | 2.20 | 89,100 | 196,020 | 2.20 |
| Missouri | 10,000 | 31,200 | 3.12 | 6,000 | 18,600 | 3.10 |
| Montana | 60,000 | 336,000 | 5.60 | 68,400 | 383,040 | 5.60 |
| New Mexico | 450,000 | 1,359,000 | 3.02 | 400,180 | 1,200,540 | 3.00 |
| Ohio | 275,000 | 811,250 | 2.95 | 321,000 | 963,000 | 3.00 |
| Oklahoma | 45,000 | 176,400 | 3.92 | 40,000 | 156,000 | 3.90 |
| Pennsylvania | 20,130,000 | 40,461,300 | 2.01 | (d)27,372,018 | 56,054,428 | 2.05 |
| Tennessee | 500,000 | 1,395,000 | 2.79 | 345,000 | 966,000 | 2.80 |
| Utah | 212,368 | 654,093 | 3.08 | 347,356 | 1,076,804 | 3.10 |
| Virginia | 1,099,000 | 2,417,800 | 2.20 | 1,101,000 | 2,422,200 | 2.20 |
| Washington | 65,000 | 357,500 | 5.50 | 40,000 | 220,000 | 5.50 |
| West Virginia | 3,105,000 | 5,930,550 | 1.91 | 1,992,697 | 3,605,782 | ..... |
| Other States(b) | 2,460,000 | 9,840,000 | 4.00 | 2,500,000 | 10,000,000 | 4.00 |
| Total | 33,349,754 | $79,040,624 | $2.37 | 43,544,351 | $114,477,545 | $2.63 |

(a) Estimated. (b) Includes output of by-product coke for Massachusetts, Maryland, Minnesota, New York, Michigan, Wisconsin. (c) Fiscal year ending June 30. (d) U. S. Geol. Survey figures.

As a result of England's great coal strike during the early part of the year, American exporters had unusual opportunities for strengthening their position in the foreign trade. Unfortunately, however, an unusual activity developed in the American market at the crucial stage, so that it was impossible for those interested to realize the full possibilities of the situation. It is becoming clear that the American operators would do well to concentrate their efforts on the markets closer to the United States, instead of attempting to establish themselves in the more remote ones such as the Mediterranean, for instance. Shipments to what may be considered the real export markets showed an increase of about 25 per cent. over those for 1911; in view of the rather abnormal conditions prevailing, this cannot be considered a very substantial increase.

The near approach of the opening of the Panama Canal demands some attention because of the effect this may have on our export trade. It is almost impossible to conceive the enormous changes in established channels of traffic which this may bring about. Since this country is by far the greatest coal producer in the world, we should, with our intimate

connection with the canal be the leader in the world's coal markets instead of having something less than 50 per cent. of the business held by England. It is even suggested that this offers a solution to the question of obtaining an outlet for our enormous overproduction.

Workmen's compensation has received a further impetus during the year. It has been demonstrated that about 50 per cent. of the accidents in the coal-mining industry are due to natural or inherent hazards of the work; since this must naturally be borne by the public, the question then resolves itself into the best method of accomplishing this. It is now becoming generally recognized that this cannot be handled satisfactorily in the courts of the country, and the general trend now, is steadily toward the provision of some equable remuneration for the injured. The movement is meeting with bitter opposition, however, from insurance companies depending upon this business, and it will no doubt be a long time before the practice becomes general.

The mortality rates in the coal mines continued to show a further improvement during the year. On the basis of the number killed per 1,000,000 short tons of coal mined, a new low record was established for the last 14 years, the rate being about 4.3 deaths per 1,000,000 tons. It is gratifying to note that this rate has shown a gradual and consistent reduction during the past 5 years, since the ill-fated year of 1907, when the rate reached its maximum of about 6.9 per 1,000,000 tons. The nearest approach to the present low record was made in 1899, when the death rate was about 4.9 per 1,000,000 tons.

On the basis of the fatal accidents per 1000 men employed, the comparison is not so favorable, but, nevertheless, it shows a steady decrease. In 1912, the rate was about 3.2 per cent. as compared with the maximum of about 4.8 per cent. in 1907; the 1912 rate, however, was lower in 1896–97–98, being less than three during each of these years.

In the matter of large explosions, the year established a very fair record, there having been only two such, one at McCurtain, Okla., costing the lives of 73 men, and the other at Jed, W. Va., in which 82 lives were lost. Only one previous year since 1907 has been so free of explosions in which less than one hundred lives were lost, that being 1910, when the maximum was 83; there were, however, four other explosions in which forty or more lives were lost. It is believed that the country is making commendable improvements in this direction, and it is to be hoped that still further reductions will be effected.

No important mechanical improvements have been developed during the year. A broadly known and more general adaption, however, of existing mechanical devices has been noticeable. The turbine is coming into more general use, slowly but surely displacing the old reciprocating

engine; there has also been a decided tendency toward central power stations and the use of electric machinery is becoming more common each year. Nor have there been any important strides in the sciences. Probably the most important discovery has been the conclusive proof of the fact that ethane and carbon monoxide do not emanate from the coal in the mine. In England it has also been shown that stone dusting cannot be a cause of tuberculosis unless the stone be of a particularly sandy character. LeNaire has also effectively demonstrated the safety to be obtained by covering the shot hole with stone dust.

## Review of Coal Mining by States

*Alabama* (By G. B. Allen).—This state produced 16,100,600 during the year of 1912 showing an increase of 1,079,179 over the previous year's output. The output of coke in 1912 was 2,975,489 tons.

There have been no strikes or other labor disturbances in any quarter, although here and there at certain seasons there have occasionally been slight temporary shortages of labor. A considerably larger number of men have been employed in all directions. No serious accidents have occurred, excepting one in Tuscaloosa County, where 18 men perished in a gas explosion.

During 1912 McCormack & Ramsey, of the Pratt Consolidated Co., purchased the Newcastle properties from the Anniston Iron Corporation. Eight hundred tons are being mined daily and it is expected to greatly increase the output in the early part of 1913.

The Woodward Iron Co. absorbed the Birmingham Coal & Iron Co.; the Bonnyman-Norman Coal & Iron Co. took over the Coalmont Mine of the Helena-Cahaba Mining Co., and a small property near Brookside. These were the only consolidations of consequence.

Unfortunately there was a shortage of cars in September, October and November, and at times this was the cause of some embarrassment; the situation in this respect began to improve in December, however, and no particular complaint on this score was heard later.

The Tuscaloosa Mineral R. R. (property of the Louisville & Nashville R. R.), operating between Birmingham and Tuscaloosa (56 miles), was opened for traffic in the spring of 1912. This line will develop a large tract of valuable mineral lands, which will naturally inure greatly to the general prosperity of the Birmingham District.

*Colorado* (By Jas. Dalrymple)[1].—Production in this state for the year 1912 totaled 10,977,824 tons.

The condition of the coal industry in the state of Colorado for 1912

[1] State Inspector of Coal Mines, State Capitol, Denver, Colo.

has been wholesome and normal and there has been a steady increase in the production over that of 1911. The demand for coal in 1912 has greatly exceeded the production. This was due, in a measure, to the better financial conditions prevailing in the country. The operators have been seriously handicapped, however, both by a shortage of miners and a shortage of cars.

Coal is now mined in 18 counties in this state and 90 per cent. of the mining is done by hand, while machinery is used for the remaining 10 per cent. For the latter, electrical machinery and compressed air are used.

The number of new mines started and old mines reopened is fifteen. The total number of mines in operation this year is 158. The average number of men employed during the year was 13,713.1, and the number of days worked was 186.4.

The number of fatal accidents recorded to Dec. 1, 1912, has been 92, while the non-fatal for the same period has been 291. Most of the fatal accidents are still due to falls of roof, although there have been several gas explosions this year. The most disastrous explosion occurred in the Hastings mine, Las Animas Co., June 18, 1912, when twelve men met their death. In the Piedmont mine, also in Las Animas Co., on Aug. 29, 1912, the superintendent and the mine boss were killed by a gas explosion. A gas and dust explosion in the South Canon mine, in Garfield Co., on Oct. 1, 1912, killed two men, and the night foreman of the Simpson mine, in Boulder Co., was killed on Nov. 9, 1912, by an explosion of gas.

There have been but seven coke plants operating in the state during 1912 and the production has amounted to 928,917 tons, some of which has been shipped from Colorado, although the bulk has probably been used at the smelters throughout the state. A very superior grade of coke is produced here. The Sopris coke, which possesses a quality particularly adapted to the production of steel, is used exclusively at the Minnequa Steel Works, which contracts for the entire Sopris output of coke.

*Idaho* (By R. N. Bell).[1]—There are several scattered deposits of tertiary lignite in the state that have in no place proven of commercial value so far, and are confined to small ancient lake-bed areas and margins.

In the Teton Basin in Fremont County, a limited area of the rich coal bearing Cretaceous formations of western Wyoming extends across the Idaho state line and embraces a few townships. In one of these, at Horse Shoe Creek, some interesting coal deposits are under slow process of development and have been tested to sufficient extent to warrant the anticipation of an important local supply of desirable coal in the near future. The most extensive point of development

[1] Mine Inspector, Boisé, Idaho.

has been on the Brown Bear claim, and all that has been done has been by the original discoverers without any outside capital.

*Illinois* (By Martin Bolt).—The coal production of Illinois reached the highest point in the history of the industry during the year ending June 30, 1912. The total tonnage amounted to 57,685,700 tons, an increase over 1911 of 7,349,141 tons. This increase is the more remarkable when it is considered that the shipping mines, which produce 97 1/2 per cent. of the total product, have decreased in number.

While the number of men employed and the number of days worked have increased for the year, the rate is not in proportion to the increased product. The average daily output for each man employed is 4.27 tons, while 3.87 tons was the daily average for 1911.

There has been a considerable increase in the number of mines using machines, in the number of machines in use and in tons undercut. The increase in machine mines is 13; while increase in machines themselves is 151 and in tons undercut is 5,551,760. This method of mining has steadily increased from year to year until more than 44 per cent. of the total output is mined in this way.

The number of men killed while in the discharge of duty was 180, and 800 men were injured so as to lose 30 or more days from their employment. The increase in number of fatal casualties is in exact proportion to the increase in tonnage which is 14.6 per cent. Most of the accidents in the mines in Illinois are caused by falling coal and rock and by mine cars and motors.

There are no reports on the mines for the last half of the year 1912, except in a general way and these indicate a healthy activity in all sections where coal is produced in large quantities. The tonnage produced in the last half of 1911 was nearly 31,500,000 tons and there is no reason for estimating the output at less than that figure for the same period this year. It will probably reach a higher point, if the same rate of increase is maintained.

The activity is due largely to the fact that an early agreement between the operators and miners in regard to the wage scale was reached, thereby giving the operator a better opportunity to secure contracts for the year.

*Indiana* (By Frank I. Pearce).[1]—The mining situation in Indiana during the fiscal year ending Sept. 30, 1912 was peculiar in some respects. The first half of October, the demand for coal began to improve somewhat, and from this period to Dec. 30, the mines averaged a little better than half time. A number that were closed down earlier in the year resumed operations.

[1] Deputy Inspector of Mines and Mining, Indianapolis, Ind.

All of the mines in Indiana, except one or two very small producing mines, stopped work Apr. 1, 1912, pending a settlement of the wage agreement. Work in the bituminous field was not resumed until June 1, and in the block coal field June 10, 1912. Both wage agreements were bitterly contested, and before a settlement was finally reached it was necessary to submit them to the miners for a referendum vote. The agreements submitted to the miners were carried by overwhelming majorities, giving to the Indiana miners the highest price ever paid for mining coal.

Immediately on the signing of the wage agreements a few of the mines resumed operations, but at most of them considerable repairs and cleaning up had to be done, and as a result it took several days to restore them to their normal condition.

The aggregate wages reported from the bituminous field was $12,302,947.71, making a fraction over 0.898 cents per ton for the labor cost for the total production of bituminous coal. The total wages reported from the block coal field was $786,053.61, or a fraction over $1.53 per ton for the labor cost for the total production of block coal. There was a considerable increase in the labor cost per ton for total production of both the bituminous and block coal over any previous year.

The market prices for bituminous coal during the period from Oct. 1 to Dec. 30, 1911 (except yearly contracts) ranged from $1 to $1.35 per ton for mine-run bituminous coal (f.o.b. mine) and for screened block coal from $1.90 to $2.25 per ton (f.o.b. mines).

From Jan. 1 to March 30, 1912, selling prices for mine-run bituminous coal (except yearly contracts) ranged from $1.35 to $1.90 per ton (f.o.b. mine) and the price of screened block coal ranged from $2.25 to $2.75 per ton (f.o.b. mine). The higher prices paid during this latter period, were due to the 2-year wage agreement between the miners and operators, which expired on the last day of March and with its expiration came the likelihood of a lengthy suspension of work at the mines.

From June 1 to Sept. 30, 1912, the selling price of mine-run bituminous coal (excep tyearly contracts) ranged from $1.15 to $1.20 (f.o.b. mines), and for screen block coal the prices ranged from $2.05 to $2.20 (f.o.b. mine).

The total number of employees reported for the year was 21,230, an increase of 452 over the first 9 months of the year 1911. Of this number 19,703 were bituminous and 1527 block-coal employees.

The total wages reported from the bituminous field being $12,302,-947.71, show an average earning of $624.42 for each bituminous employee, and the total wages paid to block-mine employees being $786,053.61,

show an average earning of $514.77; the aggregate wages for the state being $13,089,001.32, and the total number of employees in the state 21,230, show an average earning of $616.53 for each mine employee in the state.

Nine new mines, and other seams in seven mines already in operation, were opened up. Eighteen mines, and the seams worked by three others, were abandoned during the year ending Sept. 30, 1912.

Notwithstanding the two months' suspension pending the adjustment of the wage agreement and a number of days lost at some of the mines on account of car shortages and a number of local strikes, the total production for the year was 14,204,578 short tons. The total production of bituminous coal was 13,690,878 tons, while the tonnage of block coal reached 513,700.

A fraction over 51.8 per cent. of this was mined by machines, the electric chain cutters predominating. In only 1 year (1910) in the history of the state was this production excelled, when the miners of Illinois were on strike for 7 months, giving Indiana the opportunity of additional markets north and northwest. These could not have been reached if the mines in Illinois had been working.

In Indiana, 8,023,701 tons of the bituminous coal were consumed during the year; 5,667,177 tons were shipped to other states. A fraction over 57.88 per cent. was consumed in Indiana. This shows an increase of about 1 per cent. in the home consumption of the yearly production over any previous year. The aggregate wages reported for the year was $13,089,001.32.

*Iowa* (By L. E. Stamm).[1]—Coal has been mined in Iowa since 1840, the first coal being mined several years prior to Iowa becoming a state. During the first several years that coal was produced, the output was small and was mined only for domestic use. Later, with the growth in population and the advent of the railroads in the state, the production increased each year, and considerable coal was shipped to the North and West.

From 1900 to 1906 the production each year was more than 6,000,000 tons. Since then the tonnage produced by the state has reached more than 7,000,000 tons each year until the fiscal year ending June 30, 1912, when the output was slightly under the seven million mark. I believe that the production for the calendar year 1912 will approximate that for the fiscal year.

Development work is progressing in the new mines in Marion County along the new extension of the Rock Island Railroad from Des Moines to Allerton. These new mines will add much to the output of the Second

[1] Secretary, Iowa Mine Inspectors, Des Moines, Iowa.

District this coming year. New mines are also being developed in Monroe and Polk Counties. Owing to the warm weather which has prevailed this fall the work in mining has been but fair, but from now until March the mines of Iowa will run at their full capacity.

During the last year there have been but few labor troubles affecting the production of coal. Local strikes or difficulties were usually settled within a day or two, and none of these at any time seriously affected the output of coal. Such troubles as arose at the mines were usually caused by a difference of opinion as to the construction to be placed on the agreement between the miners and operators.

An agreement between the miners and operators of Iowa as to wages and working conditions in and around the mines of this state and extending until Apr. 1, 1914, was entered into the latter part of last May, thus giving assurance that the coal industry of Iowa will be free from serious disagreements or disturbances between the contracting parties during the life of the agreement. We therefore look forward to an increased tonnage in this state for the year 1913.

*Kansas* (By Leon Besson).[1]—The year ending Dec. 31, 1912, was one of the most prosperous recorded in the mining industry of the state. The coal production exceeded the output of 1911 by almost 700,000 tons, and will reach near the 7,000,000-ton mark.

The increase in production in Kansas for the year just ended can be attributed to two causes: First, the negotiating of a wage contract without any resort to strikes or shutdowns. Second, to the decrease in output of natural gas and an increase in the price of fuel oil.

There were 27 fatal accidents during the year, most of which were caused by falls of rock. This is a considerable decrease from last year. Crawford County ranks first in point of coal production, producing more than half the output of the state. Cherokee County ranks second in the matter of coal output.

*Kentucky* (By C. J. Norwood).[2]—Based on the returns for 11 months ending Dec. 1, the output of coal for the state of Kentucky was approximately 15,500,000 tons. Estimating the production by districts, we have as follows: Western district, 7,435,500 short tons; southeastern, 4,880,900 short tons; northeastern, 3,163,100 short tons, making a total of 15,479,500 short tons.

This indicates an increase of more than 1,550,000 tons over the commercial output for 1911, and an increase of about 760,000 tons over that for 1910. The latter year held the highest record up to the year 1912.

A complete record of the mine fatalities has not yet been received.

[1] State Mine Inspector, Pittsburg, Kan.
[2] Chief Inspector, Lexington, Ky.

[illegible] indicate that during 1912 there was a material reduction in the number of deaths from falls of roof. Five deaths from [illegible] and five persons were killed by a gas explosion in the Central mine. A gas explosion in the Coil mine [illegible] in the death of five miners.

*Maryland.* By William Walker.[1]—It is gratifying to find Maryland [illegible] Business during the year 1912 has been quite favorable. There was a period of dullness in May and June, but despite the fact there will be an increase in tonnage over 1911. The production in that year was 4,166,236 tons. The mining companies report an increase for 1912, and I estimate the total will be 4,500,000 gross tons.

The following list comprises the new coal-mining companies organized during the year: Maryland-Georges Creek Coal Co., Mertins Bros., managers; Allegheny Coal Co., Edwin Roberts, manager; Moscow Iron Co., of Barton, Oscar Batdorff, manager; and the Ajax Coal Co., with James G. Pugh, president. The latter mines are situated in Garrett County, Maryland.

Eleven fatal accidents occurred during the first 8 months of the fiscal year, commencing May 1, 1912.

*Montana* (By J. B. McDermott).[2]—The total tonnage produced in Montana for the year ending Oct. 31, 1912, was 3,143,799 tons, valued at $5,600,007. The number of men employed inside was 3057, and outside, 541; while the average number of working days was 195. The number of fatal accidents was less this year than last, a total of ten against thirteen last year; but the production was the largest reported for a like period in the history of the state.

In the last published biennial report mention was made of some new properties opening up in what is known as the Roundup field. The mines were then, according to county lines, divided between Fergus and Yellowstone Counties, but are now in the baby county, Musselshell. The latter, instead of being a helpless infant this year, stands the second largest producing county in the state; Cascade, which for many years led in the production of coal, gave up first place to Carbon in 1909, and second place to Musselshell this year.

The labor unions throughout the state of Montana are agitating the subject of workmen's compensation and have practically agreed to adopt the Washington law as a model. This will probably be welcomed by the majority of coal-producing operators of the state.

The Madison and Missouri Rivers are being harnessed up and power

[1] Chief Mine Inspector, Midland, Md.
[2] Chief Coal Mine Inspector, Helena, Mont.

In some districts the increase will amount to 10 per cent., in some 8, while in others it may only be 5 per cent.

While the tonnage for the year may not reach that of the year 1910, which was approximately 34,500,000 tons, it will, in all probability, increase 2,000,000 tons over that of the year 1911.

The tonnage for the year 1912 would undoubtedly have been much greater had the mines not been handicapped by an insufficient number of cars to move the product. The car shortage for the winter months of the year 1912, was the worst experienced in years, in fact a coal famine was threatened, which only seems to have been averted by the unusual climatic conditions, which rendered the situation less acute.

The situation became so serious that an investigation was made at the instigation of the Public Utilities Commission of the state, and while their report has not been completed, the investigation has so far developed the fact that while there was no doubt as to the existence of a car shortage, it was due largely to the inability of railroads to move them, from some cause, from one point to another after they were loaded and discharged. The output of eastern Ohio would have been much greater had it not been for this drawback. The Hocking Valley operators did not suffer to so great an extent from this cause as did those in other parts of the state.

The number of employees in the mines of the state will not be materially changed from that in the year 1911, when it comprised some 48,000 persons.

The average time worked in the mines of the state will vary in different districts. In some it will average one-half, in others two-thirds, while in some it will amount to three-fourths of full time.

The highest price ever paid for producing the coal ready for the market was made possible by a wage agreement entered into between the miners and operators of the state for a period of two years, commencing Apr. 1, 1912, and ending Mar. 31, 1914. An increase of 5 cents was granted on pick-mined, screened lump coal, and 4 cents on machine-mined, screened lump coal per ton, 3 1/2 cents of which was an increase on the wages of the loaders, while the 1/2 cent was added to the wages of the machine runner.

No important strikes occurred during the year. The wage-scale agreement which will last for a period of two years makes strikes of statewide importance almost an impossibility.

Up to Dec. 27, 133 fatal accidents have been reported, which is an increase of twenty-four over the year 1911. Ninety-nine were due to falls of roof and coal, and accidents due to mine cars increased from eight to thirteen.

While no explosions or mine catastrophes of any importance occurred in the mines of the state during the year, the greatest care and precaution have been necessary in order to prevent such unfortunate events on account of mine fires breaking out in many of the large mines; good judgment, however, was exercised in handling them, and one mine which is considered unusually dangerous, is now sealed up and will not be reopened until every vestige of fire has been extinguished and there is no possible danger to life or property.

Twenty violations of the mining laws were reported during the year, and fines amounting to $170 were assessed. One mine official was arrested for not supplying the required amount of ventilation; the other offenders were mine employees. Eight machine runners were prosecuted for not having the necessary shield on the machines, as required by law. Other offenses were: Riding on mine-car trips, 3; using impure oil, 3; using steel tamping tools, 2; crossing a danger signal, 1; and conveying powder while the electric current was on the wires, 1.

The outlook for the year 1913 is exceedingly promising, especially if present conditions prevail; and if industrial and manufacturing concerns maintain their present activities, this year should be even more prosperous than 1912, and in consequence, coal, which is our prime commodity, will also increase in tonnage.. The year 1912 from many standpoints was a most unusual one, and notwithstanding the fact that it was a presidential year, the coal trade did not suffer.

*Oklahoma* (By L. C. Snider).[1]—All the coal in Oklahoma lies in the eastern portion of the state and the greater part of the deposit is in an area comprising parts of five or six counties in the east-central section. This main area is underlaid by seven workable seams of coal. A belt runs from this area north to the Kansas line. It has three or four beds of coal, which are mined by underground workings in the south end of the belt and stripped by steam shovels at the end near the Kansas line. The area is thus continuous with the Kansas field to the north and the Arkansas field to the east. The coal from the different seams does not vary to any great extent. All supply a good quality of bituminous coal.

The production of coal began to be recorded in 1880 when 120,947 tons were produced. The production gradually increased until 1903 when the output rose to over 3,500,000 tons. Since 1903 the production has remained nearly stationary at very near 3,000,000 tons except in 1907 when it reached 3,642,658 tons, with a value of $6,253,567 the greatest output for any year up to the present. Since 1907 the yearly output has been as follows:

[1] Geological Survey of Oklahoma, Norman, Okla.

OUTPUT OF COAL IN OKLAHOMA.

| Year. | Quantity. | Value. |
|---|---|---|
| 1908 | 2,948,116 | $5,976,504 |
| 1909 | 3,119,377 | 6,253,367 |
| 1910 | 2,646,226 | 5,867,947 |
| 1911 | 3,074,242 | 6,291,494 |

The principal causes for the lack of development during this period have been the strong competition of gas and fuel oil in adjacent territory and the mining and labor conditions which make the production cost higher than it is in other states so that coal from other fields can compete with the Oklahoma coal inside the state in spite of the difference in freight rates.

During 1912 the trade conditions have been somewhat better than in 1911 and a substantial though not a phenomenal increase is promised. From preliminary reports the indications are that the production will be in the neighborhood of 400,000 tons greater than that of 1911, which will make it between 3,400,000 and 3,500,000 tons. The value at the mine ruled a few cents less per ton than in the previous year, but the value for 1912 should be about $6,750,000 thus establishing a new high record for values.

*Pennsylvania* (By Frank Hall).[1]—Pennsylvania will attain to still greater distinction this year as a coal-producing territory by reason of the fact that the bituminous output will reach the unprecedented volume of 160,000,000 net tons, the largest annual production in the history of the industry. The anthracite output may reach 85,000,000 net tons.

In both regions a shortage in the car supply lessened the shipments to some extent. In the bituminous region the complaint has been loud and persistent regarding this check to trade. The inability of many of the mines to obtain sufficient labor has also tended to restrict the output.

In the anthracite region, many of the mines have reached their maximum capacity and some of them have passed beyond that point, and it may therefore be predicted that the future annual production will never greatly exceed the output of the present year. The culm banks, which have been furnishing a great deal of marketable coal of the smaller sizes, are about exhausted, and thus less coal of this grade will be marketed in the future.

In the bituminous region, the number of employees was approximately 185,000, and the number of fatal accidents in that region will total to about 450, a decrease from last year, when the number was 515.

[1] Deputy to the chief mine inspector, Pennsylvania Department of Mines, Harrisburg, Penn.

The number of days worked was about 235. In the anthracite region, the number of employees was approximately 174,000, and the number of fatal accidents will total about 600, a slight decrease from last year. The number of days worked was about 220.

The number of accidents which occur in mining operations are unfortunately increased by the rushing methods of operation which naturally result after the mines have been idle for a period of several weeks and the supply of coal approaches exhaustion. The strenuous effort made to extract enough coal to meet the demand at such times adds greatly to the hazard of an occupation that is fraught with danger even if the operations are carried on with the greatest care.

There were, however, no accidents of unusual magnitude. Several mine fires occurred, but they were only moderately destructive. Two floods of the character of cloud-bursts caused the destruction of much property in the Fifth, Seventeenth and Twenty-sixth Bituminous Districts. In addition to the property loss in the Fifth District, eighteen mine employees were drowned.

The production of coke will probably reach 22,000,000 tons, the year closing with business extremely brisk and prices satisfactory. The same may be said of the coal industry, and the prospects for the coming year for both lines of trade seem to be extremely bright.

The anthracite production would no doubt have been greater had not a suspension of about 7 weeks occurred during the months of April and May, pending the settlement of the differences between the miners and the operators and the signing of an agreement for the coming year. The bituminous trade was not much disturbed by strikes, although some local suspensions of activity occurred for short periods.

MONTHLY AVERAGE PRICES FOR CONNELLSVILLE COKE FOR 1911.
(Per 2000 lb. at ovens.)

| Month. | Furnace. | Foundry. | Month. | Furnace. | Foundry. |
|---|---|---|---|---|---|
| January | $2.60 | $3.05 | July | $1.65 | $2.15 |
| February | 2.25 | 2.75 | August | 1.65 | 2.15 |
| March | 2.00 | 2.60 | September | 1.60 | 2.15 |
| April | 1.80 | 2.40 | October | 1.55 | 2.10 |
| May | 1.70 | 2.25 | November | 1.45 | 2.00 |
| June | 1.65 | 2.20 | December | 1.50 | 2.00 |

CONNELLSVILLE REGIONS COKE PRODUCTION.

| Year. | Short Tons. | Year. | Short Tons. |
|---|---|---|---|
| 1907 | 19,400,327 | 1910 | 18,689,722 |
| 1908 | 11,133,173 | 1911 | 16,334,174 |
| 1909 | 17,785,832 | 1912 | 20,000,873 |

The operators generally have been making more improvements than usual about the mines, and in accordance with the act of June 15, 1911, all inside buildings have been made incombustible. Many mines also are now equipped with the most modern and complete electrical haulage apparatus and lighting system.

One notable feature in the bituminous industry has been the recent acquisition by the Pittsburgh Coal Co. of the mines of the Monongahela River Consolidated Coal & Coke Co. and the New York & Cleveland Gas Coal Co. This addition to the present operations of the Pittsburgh Coal Co. will give it a daily capacity of 100,000 tons.

In the anthracite region two new mines were opened during the year, both in the Sixth District. In the bituminous region 46 were opened, 2 in the 2d District, 6 in the 3d, 6 in the 4th, 1 in the 5th, 1 in the 6th, 4 in the 8th, 3 in the 12th, 1 in the 17th, 6 in the 18th, 4 in the 20th, 1 in the 21st, 3 in the 23d, 3 in the 24th and 5 in the 25th.

*Tennessee* (By Geo. E. Sylvester.[1])—The 1912 output is probably not materially different than for several years past. This year has been free from any general disaster, and the death rate has been materially lowered, being only eighteen from inside accidents. There was but little labor trouble during the past 12 months, although many of the mines ran on short time at various periods on account of dull season or car shortage. Business with the mines at present is good, and practically all companies are running full time.

*Utah* (By J. E. Pettit.[2])—We close the fiscal year Nov. 30, 1912, with the largest increase in output of coal and coke for any one year in the history of the state. The output of coal increased 586,885 tons, or 23.46 per cent., and the coke production was augmented but the extraction of hydrocarbon minerals other than coal decreased 3393.69 tons, or 9.1 per cent.

The most important reason given for the large increase in coal has been the demand for our coke. During the past year, 603,446 tons of coal were used in the manufacture of coke against 365,822 tons for 1911. The increase in the use of coal in the state for the past year is also noticeable. The amount used in 1911 was 2,124,500 tons, and in 1912, 2,466,745 tons, while our exports to neighboring states increased from 418,671 tons to 463,349 tons in the same period of time.

The distribution of coke provides some interesting figures. The Nevada smelters received 31,563 tons, against 335 tons in 1911. The Montana smelters increased their order from 86,714 tons to 135,865

[1] Chief mine inspector, Nashville, Tenn.
[2] State mine inspector, 501 Dooly Block, Salt Lake City, Utah.

tons. Idaho used 894 tons for that purpose, while Utah increased her smelter demand from 123,752 tons in 1911 to 176,426 tons in 1912.

The decrease in the output of the hydrocarbon product is due to peculiar Eastern conditions, by which its market is governed. The sale of this mineral seems to be intermittent, one month the mines are working to full capacity, the next month the forces are reduced.

We have had no labor troubles during the past year. The wages of those employed in and around the mines and coke plants remained practically the same as in the previous twelve months, and, from close observation, we are convinced that a good feeling exists between employer and employed.

The selling price of coal remained the same as in 1911; however, the market price for the hydrocarbon mineral is somewhat lower. No serious shortage of cars has been reported during the year, except in latter part of September and October.

Three new coal properties, viz., the Willow Creek mine, operated by the Utah Fuel Co.; the Panther Cañon or Cameron mine, operated by the Castle Gate Coal Co., and the Neslen mine, operated by the American Fuel Co., have been added to the list of shippers during the past year.

The Storrs mine, being developed and equipped by the Spring Cañon Coal Co., will be shipping coal by Feb. 1. A railroad 4 1/2 miles in length has been built to the mine connecting with the main line of the Denver & Rio Grande R. R. Co., 1/2 mile west of Helper.

The coal production for 1912 was 3,088,356 tons, making an increase of 586,885 tons over that of the preceding year. The coke production was 347,356 tons, an increase of 134,988 tons. The hydrocarbon production was 33,656.31 tons, or a decrease of 3393.69 tons.

The miners used 351,505 lb. of black powder and 395,218 lb. of giant and permissible powders, a total of 746,723 lb., or about 1 lb. of powder for every 4.13 tons of coal mined.

The men employed in and around the collieries, hydrocarbon mines and coke plants, aggregated 4063 during the year, or an increase of 265 men over those employed in 1911. The average number of days worked by the regular producing mines was 280 days.

*West Virginia* (By John Laing).[1]—On account of the unsettled labor conditions in this state during the past few months and also because of the inadequacy of the car supply which has been extremely short, the production of West Virginia has been much constricted. However, as will be seen, we produced a little over 5,500,000 more tons gross in 1912 than we did in the preceding 12 months. I believe that had it not been for the labor troubles and the short car supply that the production

[1] Chief of Department of mines, Charleston, W. Va.

in the calendar year would have been at least 63,000,000 gross tons, but, as it is, I think we produced approximately 60,000,000.

Including superintendents, mine foremen, fire bosses, store and office clerks, there are 79,781 persons employed directly in and around the mines of this state. The mines have operated 218 days during the calendar year 1912.

Many improvements have been made at the various mines throughout the state and about 25 new mines have been opened; 38 power plants installed; 30 to 35 up-to-date fans erected; 35 tipples built and 38 additional openings made at old mines.

In my opinion, the development of the coal in this state is in its infancy. The next 10 years will show such a marked improvement in the coal industry that the years prior to this will be almost entirely forgotten as periods of mining development in West Virginia. Furthermore, unless all signs fail, we will have the largest output of bituminous coal of any state in the Union.

The operators throughout the state report a marked improvement in the demand for West Virginia coal during the past year over that of the preceding 12 months, and the prices have advanced with the demand.

The statistics which follow are for the fiscal year ending June 30, 1912: The total coal production during the fiscal year was 59,581,774 gross tons of coal or an increase of 5,548,588 gross tons over that of the year ending June 30, 1911, or 10.26 per cent. The coke production was 1,992,697 net tons, a decrease of 701,350 net tons under that of the year ending June 30, 1911, or 26.03 per cent.

The total value of the coal produced this year was $56,602,685.30 and the total value of the coke was $3,605,781.57. Thus the coal produced, netted the operators an average of 95 cents per ton, f.o.b. cars at mines, and the coke brought an average yield to the operators of $1.81 per ton at the same point.

During the year the mines worked an average of 224 days, employing, including superintendents, mine foremen, fire bosses, store managers, store and office clerks, miners and other mine workers, a total of 79,781 persons. Of this number there were approximately 50 per cent. white Americans and 13,403 negroes, the balance being foreign labor.

There were 409 lives lost in connection with mine operations, 392 of which number were killed inside and 17 outside the mines. There were 840 non-fatal accidents, 759 of which occurred inside and 83 outside. This shows an increase of 79 fatal accidents and 21 non-fatal accidents over the preceding year. This increase was due to explosions in the Standard Pocahontas Coal Co.'s mine (Aug. 1, 1911), the Bottom Creek Coal & Coke Co.'s mine (Nov. 20, 1911), and in the Jed Coal & Coke

Co.'s mine (Mar, 26. 1912). Had it not been for these unfortunate accidents, the number of persons killed and injured by usual causes would have been reduced substantially.

Exclusive of the lives lost in the explosions, most of the fatalities were caused by falls of roof and coal. We find that 85 per cent. of them are caused from carelessness.

*I. C. White.*[1]—The year 1912 has been a prosperous one in West Virginia so far as her mineral industry is concerned. In spite of the Paint and Cabin Creek coal strike which practically paralyzed the coal output in those two districts during a large portion of the year, the total production of coal in the state exceeded that of any previous year by several million tons.

*Virginia* (By E. W. Parker).[2]—The state of Virginia mined 7,846,638 short tons of coal in 1912 valued at $7,518,576.

Virginia recorded a notable increase in coal production in 1912, with a total output of 7,846,638 short tons for the year, valued at $7,518,578. Over 75 per cent. of the total increase was made in Wise County, in the Appalachian field, whose production in 1912 amounted to 4,500,174 short tons, against 3,754,360 tons in 1911, a gain of 745,814 tons, or nearly 20 per cent.

In the Geological Survey's coal report for 1911 mention was made of the unfavorable comparison Virginia makes with the other States of the Appalachian province in the quantity and percentage of coal shot off the solid, and this was accentuated by the record made in 1912, when out of a total of 7,846,638 short tons, 3,741,533 tons, or 47.7 per cent., was "mined" by powder. In 1911 the proportion so mined was 35.6 per cent. There was, however, an increase in 1912 in the quantity and percentage of coal mined by machines. The number of machines reported in use increased from 156 in 1911 to 185 in 1912, and the machine-mined coal increased from 2,551,627 tons, or 27.2 per cent. of the total, to 3,205,504 tons, or 40.85 per cent.

As the percentage of coal shot off the solid in Virginia is high so is the death rate. In 1912 there were 75 fatal accidents, of which 67 were underground and 8 on the surface. Half of the deaths, or 33, inside the mines were due to falls of roof, 10 to explosions or burns of gas, 10 to premature blasts or similar accidents, and 9 to mine cars and locomotives.

*Wyoming* (By E. W. Parker).[3]—The coal production of Wyoming in 1912, amounted to 7,368,124 short tons, valued at $11,648,088. The output in 1912 was the largest in the history of the State with one exception (1910), but in 1910 conditions were abnormal, a shortage of fuel

[1] State Geologist.
[2] *U. S. Geol. Survey.*
[3] U. S. Geol. Survey.

caused by a six months' strike among the coal miners in the central and southwestern states having caused an unusual demand upon the coal-producing districts of the Rocky Mountain States. The production in 1911, while less than that in 1910, showed a normal gain over 1909, and that of 1912 exhibited a similar normal increase over 1911. The region supplied by Wyoming coal was blessed with bountiful crops in 1912, and the metallurgical and other industries were in a prosperous condition, which was reflected not only in the increase in production over 1911 but in an advance in the average price per ton from $1.55 to $1.58.

Coal mining in Wyoming gave employment to 8036 men for an average of 235 days in 1912, against 7924 men for an average of 230 days in 1911. The labor efficiency in Wyoming is among the highest in the country, usually showing an average production per man per year of over 900 tons. In 1912 this average was 917. According to the United States Bureau of Mines, there were 34 deaths by accident in the coal mines of Wyoming during 1912, an increase of 1 over 1911.

Probably more than half of the entire area of Wyoming is coal-bearing. Coal is believed to exist in every country of the rtate, although in some portions it lies under so heavy a cover as to be unworkable under present conditions. The reserves are estimated at approximately 424,000,000 short tons, a supply exceeding that of any other state, with the possible exception of North Dakota.

COAL PRODUCTION IN THE CHIEF COUNTRIES OF THE WORLD.
(In metric tons.)

| Countries. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|
| Asia: | | | | | | |
| China | 10,450,000 | 11,970,000 | 12,840,000 | (e)13,190,000 | (e)13,000,000 | ..... |
| India | 11,147,339 | 12,865,408 | 11,870,077 | 12,240,744 | 12,448,726 | 14,942,376 |
| Japan | 13,716,488 | 13,942,000 | 14,019,626 | 15,681,324 | 17,632,710 | ..... |
| Australasia: | | | | | | |
| New South Wales | 7,850,000 | 7,992,300 | 8,132,196 | 8,304,284 | 8,833,570 | 10,044,480 |
| New Zealand | 1,831,009 | 1,904,276 | 1,941,827 | 2,210,546 | 2,099,231 | ..... |
| Other Australia | 900,000 | 870,000 | 1,183,875 | 1,710,930 | 1,740,030 | ..... |
| Europe: | | | | | | |
| Austria Hungary (c) | 48,180,849 | 49,280,786 | 49,509,016 | 47,943,109 | 49,089,892 | ..... |
| Belgium | 23,705,190 | 23,678,150 | 23,561,125 | 23,916,560 | 23,125,140 | 22,983,460 |
| France | 36,753,627 | 37,622,556 | 37,971,858 | 38,349,942 | 39,350,041 | 41,308,508 |
| Germany (c) | 205,542,688 | 215,071,345 | 217,322,270 | 222,375,076 | 234,259,061 | 259,434,500 |
| Italy | 453,137 | 421,906 | 395,600 | 562,153 | 510,029 | 360,291 |
| Russia | 21,207,500 | 22,943,794 | 24,083,000 | 24,026,000 | f 23,197,000 | ..... |
| Spain | 3,256,000 | 3,871,480 | 3,520,000 | 4,057,532 | 3,550,000 | ..... |
| Sweden | 305,000 | 300,000 | 250,000 | 302,786 | 311,809 | ..... |
| United Kingdom | 267,828,276 | 261,506,379 | 263,774,822 | 268,676,528 | 276,332,960 | 257,136,000 |
| North America: | | | | | | |
| Canada— | | | | | | |
| Western | 4,780,301 | 4,304,600 | 4,245,856 | 6,446,336 | 5,500,000 | ..... |
| Eastern | 5,730,660 | 6,599,866 | 5,200,777 | 6,564,930 | 6,602,000 | ..... |
| Mexico | ..... | ..... | 919,338 | 2,450,000 | e 1,800,000 | ..... |
| United States | 435,483,938 | 389,895,861 | 402,981,688 | 445,816,040 | 455,720,550 | ..... |
| South Africa (e) | 3,945,043 | 4,621,988 | 4,940,192 | 6,508,383 | 6,914,500 | ..... |
| Other countries (e) | 3,475,780 | 4,106,000 | 5,000,000 | ..... | ..... | ..... |
| Totals | 1,106,536,825 | 1,053,768,695 | 1,093,663,143 | 1,151,333,203 | 1,182,017,249 | ..... |

and Cape of Good Hope. (c) Includes lignite. (e) Estimated. (f)

## Coal in Foreign Countries

*Australia.*—Preliminary estimates of the coal production in New South Wales for 1912 shows that the value of the product will be about $18,000,000, exceeding the previous high record of 1908 by about 1,500,000. Shipments of coal from New Castle, New South Wales, for the 6 months to June 30, 1912, amounted to 2,218,692 tons as compared with 1,846,633 tons for the corresponding period in 1911. The increased shipments were principally to other ports of the Commonwealth and New Zealand.

The production in New Zealand for the year 1911 was 2,066,073 tons, being greater than for any previous year, with the exception of 1910, when there was a heavy demand from New South Wales because of labor troubles there. The total amount of the various classes of coals, lignite, and oil shale produced in New Zealand up to and including the year of 1911 was 33,297,621 tons.

The Mount Mulligan field in Queensland has a top seam 6 ft. in thickness, and a lower one 3 ft. thick. It is computed, on a basis of 1100 tons recovery per acre, that this field will produce 84,000,000 tons of coal. The coal is of the permocarboniferous period.

*Austria.*—Coal imports into this country for the year 1912 were 11,848,535 tons as compared with 10,873,799 tons in 1911; coke imports were 915,547 tons as compare with 703,707 tons in 1911; briquette imports were 188,884 tons for 1912, and 56,596 tons in 1911. Coal exports in 1912 were 655,106 tons as compared with 509,736 tons in 1911; coke exports were 349,384 tons in 1912, against 200,015 in 1911, and briquette exports were 150,335 tons in 1912 as compared with 133,917 tons in 1911.

*Asia.*—An important but as yet unreported discovery of coal was made in 1908 on the southern boundary of the Rantau Forest Reserve south of the Salangor River and about 7 miles west of the Rawang Railway station. The coal is apparently of more recent age than the Cretaceous and probably belongs to the early Tertiary. In quality, it is black, lustrous, of a distinct conchoidal fracture, and has been found from 24 to 50 ft. in thickness.

*Belgium.*—The Belgian coal production for 1912 amounted to 22,983,460 as compared with 23,125,140 tons in 1911, and 23,927,230 tons in 1910. The decrease during 1912 was due in part to the strike in Borinage district and in part to the reduction in the working time to 9 hours. It is estimated that the strike which lasted over a month caused a reduction of about 500,000 tons in the production which would, there-

fore, have been far in excess of that for 1911 had the suspension not occurred.

*Bulgaria.*—The coal deposits of this country belong mainly to the upper Cretaceous formation and occur in the central Balkans near Redevtsi. The consumption of coal in Bulgaria is estimated at 400,000 tons per annum. The government works the lignite property at Pernik, the production of which was 294,394 tons, which is used mainly on the state railway.

*Canada.*—The collieries on the Pacific Coast had, up to 1912, produced over 22,000,000 tons of coal. New fields were opened up on the western slope of the Rocky Mountains beginning in 1900. These produced, in 1910, 1,365,119 tons of coal, in addition to 215,696 tons of coke; but in 1911 labor troubles cut the production down to 337,401 tons of coal and 66,005 tons of coke. The production of the Crows' Nest Pass Coal Co., one of the largest operators in British Columbia, was approximately 1,078,000 tons in 1912, as compared with 335,000 tons in 1911; the coke production from these mines was 246,000 tons in 1912, as compared with 57,000 in 1911. In 1911 the mines of this district were closed from April until the end of the year by a strike; this has since been settled and accounts for the much heavier production in 1912.

In Nova Scotia an advance in coal prices was reported early in 1913 of about 12 per cent. Mine-run coal is now quoted on the basis of $5 per ton. Since 1907 the increase in price has been approximately 45 per cent.

*Chile.*—This country obtains coal from Great Britain and Australia, and also from the mines at Punta Arenas. The local coal is of such a soft character that it slacks quite rapidly, and as a result the producers are carefully investigating the possibilities of briquetting the small sizes. During the year one of the leading coal companies placed an order for a complete briquette plant to cost about $95,000. It will have a capacity of 250 tons in 10 hours, and is a German process.

During the year of 1911 over 403,050 tons of local coal were consumed as compared with 222,725 tons in 1910. Consumption of foreign coal for the same years was: 115,209 tons in 1911 and 267,122 tons in 1912.

Some of the best fuel mined occurs about 3 miles under Cornell Bay a few miles south of Talahso; this mine is about 60 years old. During the year 1912 railroad operations were for a time seriously restricted, due to the shortage of coal as a result of the miners' strike in England, from which country Chile imports about 500,000 tons of coal annually. The Chilian government railways consumed 241,629 tons of Chilian coal and 12,707 tons of the imported product.

*China.*—Production in China for the year 1911, according to the

*Montanistische Rund Schau*, was 15,000,000 tons, while the *Mining Journal* reports, according to districts, show a production of 11,000,000 tons. The chief producers in China are the Chinese Mining & Engineering Co., and the Shantung mines. The latter are 22 miles west of Mukden, in South Manchuria; the company operates nine shafts having a total capacity of 5000 tons per day. The most important of the purely Chinese mining propositions are the Toli mines 15 miles southwest of Peking. They have a tramway into the latter city, and the mines have a capacity of 1000 tons of anthracite per day.

The Chinese Engineering & Mining Co., one of the largest operators in this country, produced 1,433,546 long tons of coal during 1911, which is an increase of 254,000 tons over the output for 1910. On June 1, 1912, the mines of this company were consolidated with those of the Lanchow Company operating in the same basin only a few miles away. These latter operations have a capacity of 1500 tons per day as compared with 2000 tons for the Chinese Engineering & Mining Company.

The anthracite mines of the Peking Syndicate produced 417,190 tons in 1911, which is an increase of 60,000 tons over 1910. The Shantung Mining Co. produced 170,405 tons at one of its shafts and 288,752 tons at the other during 1911, which is a decrease of 58,937 tons and 56,709 tons, respectively, over 1910.

Coal exported from Newchwang in 1911 was 137,626 tons as compared with 114,676 tons in 1910. The exports from Tsingan, province of Shantung, in 1911, were 106,508 tons, as compared with 62,594 tons in 1910.

*France.*—The total coal production in France for the year 1912 was 41,308,508 tons, as compared with 39,350,041 tons for the year previous. Production in the Pas-de-Calais and Nord Basin in 1912 was 29,888,015 tons, as compared with 28,152,993 tons in 1911; coke production for the same period was 2,443,442 tons in 1912 and 2,328,715 tons in 1911. Production in the Alsace-Lorraine district in 1912 was 3,538,722 tons, showing a gain of nearly 15 per cent. over that of 1911; about one-half of this coal is consumed locally. Production of the French mines of Anzin in 1912 was 3,411,061 tons, 948,935 tons of which was bituminous, and 1,204,817 tons was semi-bituminous. The Mining Company of the Loire produced 787,023 tons in 1912.

The French coal market appears to be in a rather tense position. Apparently the mines are not increasing the production at the same rate that consumption is advancing. The leading coal trade and financial paper of the country said, during the year, "The production tends rather to decrease while the demand remains very pressing. Nevertheless, the fears of certain consumers, who are asking to be allowed to

contract for 2 or even 3 years at prices now prevailing, appear to us to be exaggerated." Prices for metallurgical coke are also showing a strong rising tendency; the total advance for the year 1912 has been 13.5 per cent.

The French imports of coal for 1912 were 15,966,768 tons as compared with 16,231,787 tons in 1911; coke imports were 1,122,744 tons in 1912 and 1,189,229 tons in 1911; briquette imports in 1912 were 2,788,966 tons as compared with 2,319,513 tons in 1911. Exports of coal in 1912 were 1,911,097 tons as compared with 1,336,014 tons in 1911; exports of coke were 217,557 tons in 1912 and 184,522 tons in 1911; briquette exports in 1912 were 191,690 tons as compared with 114,467 tons in 1911.

*Germany.*—Coal production of Germany for 1912 amounted to 259,434,500 tons as compared with 234,259,961 tons in 1911. The bituminous production in 1912 was 177,094,917 tons as compared with 160,742,272 tons in 1911. Lignite produced in 1912 was 82,339,583 tons as compared with 73,516,789 tons in 1911. The production of coke in 1912 was 29,141,070 tons as compared with 25,405,108 tons in 1911, and the briquettes manufactured for the same years were 24,391,701 and 21,827,667 tons, respectively.

There was a very pronounced shortage of coal developed in the German market during the year. Indeed, the situation became so acute that the Rhenish-Westphalian Coal Syndicate, which controls more than 50 per cent. of the German production, called upon its members for 5 per cent. more coal than their customary allotment; this represents about 4,000,000 tons. Four cargoes of the German product were shipped into the very heart of the French coal-fields, the mines in the latter district finding themselves utterly unable to cope with the increasing demand. English and Belgian exports into France both showed a falling off for the year, the latter to the extent of 400,000 tons, while Germany showed an increase of 188,000 tons.

New estimates of the life of the German coalfields were made during the year, the Zwickau district being placed at 150 years, the Lower Silesia at about 250 years, the Ruhr and Saar districts at 700 years.

German imports of coal in 1912 were 10,380,482 tons as compared with 10,913,948 tons in 1911; coke imports were 589,713 tons in 1912 as compared with 598,958 tons in 1911.

Exports of coal in 1912 were 31,143,115 tons as compared with 27,406,193 tons in 1911; coke exports in 1912 were 5,849,020 tons as compared with 4,559,975 tons in 1911; exports of briquettes in 1912 amounted to 2,119,541 tons as compared with 1,958,826 tons in 1911.

*Great Britain.*—Of the eight inspection districts in Great Britain

only one, South Wales, showed an increased production in 1912, and this amounted to only 67,196 tons. The York and North Midland district produced 65,356,084 tons, which is about 1,500,000 less than in 1911; Scotland produced about 40,000,000 tons or a little more than 1,500,000 less than 1911, while Newcastle produced about 28,500,000, or nearly 2,500,000 less than 1911. The gross production for all districts was 262,865,341, or 9,012,783 tons less than in 1911.

The decrease in production was due entirely to the long strike which prevailed early in the year. The total number of persons employed at the mines was 1,989,165, or an increase of 21,952 above the number employed in 1911. The decrease in the output was about 3.32 per cent., while the number of persons employed increased 2.08 per cent.

During the year England faced one of the greatest labor struggles in the history of her coal industry. It was apparent early in January that the situation was tense and a strike inevitable. This was substantiated on Jan. 12, when a vote of the miners was taken on the question and found to be overwhelmingly in favor of a suspension. The acuteness of the situation was emphasized toward the last of the month, when Lloyd's announced the prohibitive rate of 94 1/2 per cent. on insurance against a national strike.

The British admiralty at about this time chartered two vessels to carry 10,000 tons American coal to Gibraltar. The strike was inaugurated on Feb. 27, when between 30,000 and 40,000 miners in Derbyshire and Nottinghamshire laid down their tools and this number was increased to 100,000 on the day following. At the end of the week it was said that over 250,000 men in other industries had been thrown out of work.

At the end of two weeks the government intervened and attempted to effect a settlement, but without results, and at the end of the third week a bill was introduced in the House of Commons providing a minimum wage, in the hope that the trouble could be arranged in this way. A joint meeting of the miners and operators was held to discuss the details, but after being in session for 4 days the Prime Minister announced that the government had done all in its power to effect a settlement, but without results and that other measures must be resorted to; an agreement was not effected until April 6 when the strike was officially declared off.

The ultimate result of the British strike was an advance in wages of 1s., or 24 cents a week, making a total annual increase of about $4,800,000. As a result, the cost of coal to the consumer has also experienced an increase. During the year, the annual contracts with the railroads for locomotive fuel were renewed at an advance of 60 cents per ton over that for the previous year. Many other increases were also

noticeable, the Birmingham Municipal Gas Works being compelled to pay 50 cents more per ton with a further increase of 25 cents probable in 1913; since each additional 25 cents means a further expenditure of $146,000 for the gas department, the import of this will be appreciated. In London, the Gas Light & Coke Co. has been forced to expend 540,000 more per annum for its coal.

*India.*—India is now producing annually over 12,000,000 tons of coal. One of the most notable features of the Indian industry is the rapid increase in the use of cutting machines, principally by electricity. For haulage and pumping, however, this power is not being applied so extensively.

The exports of coal from Indo-China for the first 9 months of 1912 were 148,297 tons as compared with 187,039 tons for the same period in 1911. Exports of briquettes for the same period were 8,047 tons in 1912, and 5,851 tons in 1911.

*Japan.*—The coal production of the Nagasaki district, one of the most important in Japan, for 1911 amounted to 14,217,012 tons valued at $20,975,007.

The production for 1911 exceeded that for the year previous by more than 2,000,000 tons. This was due principally to the heavy demand from Asiatic and East Indian markets, because of the shortage in Great Britain, due to labor difficulties there.

For the first 6 months of 1912 the production was running rapidly ahead of that for the same period in 1911. The Kiushu collieries shipped during this period 4,349,412 tons, which was an increase of 334,000 tons over the corresponding period in 1911. In the Nagasaki district a by-product coke plant with a charging capacity of 300 tons of coal, and having the same type of oven as used at Gary, Ind., was installed during the year.

*Netherlands.*—The production of the government mines in 1912 amounted to 324,840 tons, of which 163,110 tons were exported. Wilhelmina sales averaged $2.89 and Emma sales $2.40 per ton.

*Roumania.*—Official statistics for this country show the coal production for 1911 was 131,278 metric tons as compared with 121,943 the year before.

*Russia.*—The oil industry, which for quite a while threatened to prove a serious menace to the coal operators, is now on the decline. At the Council of the Kharkof Convention of Mine Operators it was estimated that 370,000 tons of coal were used in place of liquid fuel, in 1910.

Because of the shortage in coke which in 1910 threatened to create a famine in pig iron, the government instituted an investigation as

to the productive capacity of the coke ovens in the south of Russia. It was found that these had only a possible capacity of 2,590,000 tons of coke, 242,000 tons of which were consumed by various industrial concerns, leaving only 2,348,000 tons for the manufacture of iron. This is only sufficient to produce about 2,000,000 tons of pig iron, while the amount actually manufactured is about 2,145,000 tons, thus showing there was a shortage of about 200,000 tons in the required amount of coke.

The Donetz Basin is the leading producer in Russia. The production of this field in 1910 was 16,432,000 tons as compared with 17,572,000 tons in 1909, the reduction being due in part to an epidemic of cholera and also to new innovations in equipment. The entire production from this field is used almost entirely on the railroads. The Dombrobsky field is the next in importance, the principal market for this product being in Poland. The Moscow field suffered the worst from competition with oil; the quality of this coal is rather inferior, and it cannot successfully compete with the other, unless briquetted.

During 1912 there were some items in the Russian Press regarding the possibility of importing 700,000 tons of foreign coal. Most of the coal imported comes from Great Britain, and the trade in the early part of the year was about normal, the average price level being $4 per ton. Later in the year, however, when the strike developed, a shortage became apparent, and prices reached $5.08 per ton by the end of the year. German coke was also imported quite extensively.

The coal production in European Russia for the first 9 months of 1911 was 18,520,100 tons as compared with 15,739,130 tons for the same period in 1910. This increase, however, is partly due to the epidemic of cholera, already mentioned, which caused a material decrease in production during 1910. During the same periods the number of ovens in operation in the Donetz district increased from 3894 at the end of 1910 to 4636, but in spite of this there was such a shortage of coke that imports of this product into the Polish district increased from 240,000 in 1910 to 345,000 in 1911.

In general, the year 1911 may be considered a favorable one in the Russian coal industry. No great gains were shown in the production of anthracite, which is the most important branch of the Russian coal industry, but nevertheless the trade was steady and even throughout the year.

*South Africa.*—The South African coal fields have never been closely studied, nor the area accurately mapped, so that only a meager knowledge is available, and it is impossible to make any estimates of the total quantity of coal. The development of the fields has only been started

comparatively recently, and the production is not heavy. The South African Geological Survey estimates the coal resources roughly, as follows:

Transvaal, 5000 square miles containing an average of 6 ft. of coal, or about 36,000,000,000 tons. Natal, 1000 square miles containing an average of 7 ft. of coal, or about 9,400,000,000 tons. Zululand, 1250 square miles containing coal averaging 4 ft. thick, or about 6,000,000,000 tons. In Orange Free State, Cape Basutoland and Swaziland it is impossible to make even an approximate estimate, but the total resources will probably not exceed 1000 square miles containing coal averaging 4 ft. thick, or a total of 4,800,000,000 tons, making the grand total 56,200,000,000 tons. Under present methods of working about a 55 per cent. recovery is effected.

The total coal production of the South African Union for the year 1911 amounted to 7,605,894 tons valued at $9,417,422, the price per ton varying from a minimum of $1.13 in Transvaal to a maximum of $2.80 in Cape Colony; the latter price is abnormal, however, and is due to the absence of competition, the maximum price in other states being $1.38. The amount used in the bunkering trade during the year was 1,426,586 tons, besides which there were 82,536 tons exported.

During the close of the year a majority of the coal companies in Natal completed a working agreement, under which the export trade was to be conducted. This was essentially a revival of the old Natal Coal Export Association which was dissolved 3 years ago because of the failure of its members to agree upon the tonnage allotment to the different operators; since that time prices have fallen off to such a low level that the business is unprofitable. This arrangement will also eliminate a great deal of trouble with the railroads regarding car service rules.

Production in Natal for the year 1912 was 2,470,775 long tons, as compared with 2,394,238 tons in 1911. An appreciable decline in the bunkering trade was noticeable in 1912, due to the fewer vessels from the East without cargo and also to the difficulties with the railroads regarding the equipment used in export business.

Important coal deposits were discovered during the year in Nigeria and the coal is said to have about two-thirds the heating value of the best Welch coal. The location of the field is such that it will probably assume great importance in the industrial development of the state. There were also reports of a discovery of a large coal field near Kapanga
the western shore of Lake Tanganyika. It was stated that from
n to eight seams, averaging about 6 ft. thick, had been found.
ere were several valuable reports on the coal fields of Rhodesia
d during the year. The most important coals in this state are

found in the lower Matabola division of the Karoo formation. At the present time the only important development is at Wankie, where a seam varying from 6 ft. to 12 ft. 6 in. in thickness is being worked. As a rule, the ash content of all the coals in the state is rather high, but in the Wankie and Tuli coals it is only from 8 to 13 per cent. The coal is semi-bituminous in character and has been found in places as thick as 28 ft.

*Turkey.*—The last official report of the Department of Mines and Forests of this country is for the fiscal year ending March, 1909. In that year the production amounted to 675,767 metric tons as compared with 653,345 in 1908.

*Venezuela.*—There was some activity in the development of new coal properties in this country during the year, an American company being formed to open up a deposit on the Guasare River, on the Guajira Peninsula. The supplies available are said to be so large that no approximate estimate of them could be made, and the quality of the coal was unofficially stated to be equal to the better grade American steaming fuels and practically free from sulphur, which is usually present in the Venezuela product.

IMPORTS OF COAL AND COKE INTO THE UNITED STATES. (*a*)
(In tons of 2240 lb.)

| | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|
| Canada | 1,398,194 | 1,107,737 | 1,043,419 | 1,675,602 | 980,174 | 1,404,139 |
| Great Britain | 42,830 | 36,989 | 17,225 | 13,124 | 9,278 | 8,697 |
| Australia | 552,918 | 327,441 | 182,271 | 240,889 | 232,969 | 162,671 |
| Japan | 123,720 | 31,792 | 14,344 | 56,278 | 16,031 | 30,621 |
| Other countries | 8,356 | 340 | 5,079 | (*b*) 19,576 | 356 | 2,222 |
| Total coal | 2,126,018 | 1,504,229 | 1,262,338 | 2,005,559 | 1,238,808 | 1,608,350 |
| Coke | 132,355 | 129,591 | 170,671 | 156,417 | 69,515 | 110,347 |

(*a*) Of the coal imported in 1909, there were 4709 tons classed as anthracite. Nearly all the imports were for the Pacific coast. The features of 1909 are found in the large falling off of imports from Australia and Japan. The unusual increase in the receipts of Australian and Japanese coal in 1907 was due to the expectation of a fuel famine in the West. The coke received is from British Columbia with the exception of a few thousand tons from Germany. (*b*) Includes Great Britain.

DESTINATION OF COAL EXPORTS. (*a*)
(In tons of 2240 lb.)

| | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|
| Canada | 9,843,315 | 9,252,943 | 9,782,574 | 10,531,085 | 14,108,567 | 14,048,540 |
| Mexico | 1,066,502 | 694,099 | 614,310 | 675,980 | 470,674 | (*b*) 302,427 |
| Cuba | 804,310 | 690,867 | 723,594 | 858,776 | 1,053,703 | (*b*) 1,152,004 |
| Other West Indies | 474,382 | 374,699 | 378,184 | 487,519 | 577,159 | (*b*) 650,617 |
| Europe | 220,479 | 234,581 | 255,109 | 250,060 | } 1,222,650 | } 1,459,201 |
| Other countries | 737,760 | 605,988 | 782,786 | 1,002,446 | | |
| Total | 13,146,748 | 11,853,177 | 12,536,557 | 13,805,866 | 17,432,753 | 18,148,767 |

(*a*) Does not include bunker coal. This amounted to 6,667,338 tons in 1911 and 7,340,100 tons in 1912. The European exports in 1909 were chiefly to Italy, that country receiving 156,920 tons. Other countries are chiefly the South American republics. The Canadian shipments were 78 per cent. in 1909, 76.3 per cent. in 1910 and 81 per cent. in 1911. Panama took 496,730 tons in 1911 and 462,659 tons in 1912.

## The Coal Markets in 1912

*Pittsburgh* (By B. E. V. Luty).[1]—The Pittsburgh district coal c
ators, as a whole, experienced another unsatisfactory year in 1912, fron
standpoint of financial results. Our review of 1911 noted that the re
of that year had been unsatisfactory in this way also. The prosp
for 1912 were better, and the tonnage on the whole was good. The
of mining was increased, through the wage advance, but operator
lowed for this. They made close prices and, figuring on a much l
tonnage than in 1911, expected to make a fair profit through reduc
in overhead charges per ton. The unsatisfactory financial result,
disappointment in view of the expectations entertained, is attribute
the fact that, on account of short car supply and insufficient l
operations were very intermittent and the cost of production was acc
ingly much higher than was anticipated. The supply of cars and l
was not uniformly bad throughout the year, but it was frequently p
and irregularities, by disturbing plans, produced possibly worse re
than would have occurred with a uniformly inadequate supply, w
would have caused the plan of attack to be different.

The coal market was seriously disturbed by the unexpectedly q
settlement of the biennial wage scale, an agreement being reached
tween operators' and the miners' representatives at Clevelan
Friday, March 29. While the men did not return in a body until the r
endum vote was completed, the suspension lasted only about 3 w
Probably the general expectation among consumers was that it w
last 4 to 6 weeks, perhaps longer, and stocks had been laid in accordi
so that the early resumption of mining found the trade with little
mand. Possibly the operators were hastened in reaching a settle
by the fact that on March 1 more than a million men quitted the En
coal mines, but that strike did not give the United States the den
that was expected. The wage settlement, for the 2 years to the
Mar. 30, 1914, was on the basis of an advance in the general mining
of from 95 cents to $1, following a similar advance made in the
settlement.

From November, 1911, to December, 1912, the Connellsville
region saw the most spectacular advance in prices in its whole his
the advance occurring chiefly in 1912. In November, 1911, furnace
for prompt shipment could easily be secured at $1.50, and the
contracts made for the first half of 1912 were at $1.55 and $1.60,
tracts for the whole year being made at $1.60 and $1.65. Toward
close of December the prompt price advanced sharply, a normal

[1] 627 Oliver Building, Pittsburgh, Pa.

formance as shipments are usually deficient over the holidays. In January, however, the market did not recede, but reached higher levels for prompt, while contract coke sold above $1.75. In April there occurred further advances, coke becoming scarcer on account of coal shipments due to the mining suspension in the union coal mining districts, and prompt furnace coke sold at $2.50 and $2.60.

SHIPMENTS OF ANTHRACITE.
(Tons of 2000 lb.)

| | 1910. | | 1911. | | 1912. | |
|---|---|---|---|---|---|---|
| | Tons. | Per cent. | Tons. | Per cent. | Tons. | Per cent. |
| Reading | 12,445,733 | 19.2 | 13,265,758 | 19.0 | 12,852,386 | 20.2 |
| Lehigh Valley | 11,195,765 | 17.2 | 12,603,000 | 18.0 | 11,791,601 | 18.5 |
| N. J. Central | 8,519,135 | 13.1 | 9,218,802 | 13.2 | 8,342,447 | 13.1 |
| Lackawanna | 9,589,076 | 14.8 | 9,869,620 | 14.1 | 9,065,622 | 14.2 |
| Del. & Hudson | 6,578,356 | 10.1 | 7,206,731 | 10.3 | 6,361,238 | 10.0 |
| Pennsylvania | 6,250,976 | 9.6 | 6,494,733 | 9.3 | 7,435,697 | 8.7 |
| Erie | 7,554,198 | 11.7 | 8,800,179 | 12.6 | 7,435,697 | 11.7 |
| N. Y. Ont. & West | 2,772,547 | 4.3 | 2,495,476 | 3.5 | 2,213,382 | 3.5 |
| Total | 64,905,786 | 100.0 | 69,954,299 | 100.0 | 63,610,587 | 100.00 |

*Chesapeake & Ohio Ry.*—The following is a comparative statement of the coal and coke traffic over the lines of the C. & O. Ry., for the 6 months ending Dec. 31, 1911–12, in short tons:

| Destination. | 6 Months. | |
|---|---|---|
| | 1911. | 1912. |
| Tidewater | 1,970,464 | 1,690,591 |
| East | 1,069,625 | 1,215,205 |
| West | 5,735,565 | 4,947,470 |
| Total | 8,775,654 | 7,853,266 |
| Coke | 110,597 | 134,936 |
| From Connections: | | |
| Bituminous | 117,326 | 241,000 |
| Anthracite | 18,749 | 6,971 |

*Pennsylvania Railroad.*—Statement of coal and coke carried on the P. R. R. Co.'s lines east of Pittsburgh and Erie during the year 1912 with the increase or decrease over the same period last year, in short tons:

| | Year. | Difference. |
|---|---|---|
| Anthracite | 10,312,348 | −1,644,801 |
| Bituminous | 46,434,187 | +4,014,742 |
| Coke | 13,371,345 | +2,732,238 |
| Total | 70,117,880 | +5,102,179 |

*Norfolk & Western Ry.*—The following is a comparative statement of the coal and coke shipments over the lines of the N. & W. Ry. for the years 1911–12, in short tons:

| Destination. | 1911. | 1912. |
|---|---|---|
| Coal: | | |
| Tidewater, foreign | 995,400 | 1,343,311 |
| Tidewater, coastwise | 3,084,674 | 3,583,283 |
| Domestic | 15,363,913 | 17,716,575 |
| Coke: | | |
| Tidewater, foreign | 75,867 | 52,762 |
| Domestic | 1,434,985 | 1,416,856 |
| Total | 20,954,839 | 24,112,787 |

*Coastwise Trade* (By G. G. Wolkins).—To some extent 1912 justified expectations; it was marked by uneven prices and a surfeit of anxiety over discouraging possibilities. The early adjustment of labor troubles, in the bituminous region, a day or two in advance of the expiration of old agreements, and in the anthracite field after a few weeks' suspension, deprived the year of a place with 1902, and yet it was a record 12 months for bituminous tonnage and lent zest and variety to an industry accustomed to turmoil and strife.

The collapse in both the American and the British strike situations came just in time to allow consumers to replace at low prices the reserve stocks of bituminous that had been wiped out by seven weeks of exceptional cold, and in anthracite there has been a joining of weather, of traffic, and trade accommodation that has just about enabled the average retail dealer to get along on a hand-to-mouth basis.

During January and February receipts at tidewater were so light that spot coal of the inferior kind was marked up to $1.25 and even to $1.40 at the mine, and there it fluctuated until the preferred grades disappeared from the market in March and up to $3.25 was paid the selling agencies for anything that was known to be *en route* when a country-wide strike was supposed to be imminent. The slump was so rapid in early April that operators were slow to realize what had happened and for some weeks the lowest figures were maintained in cleaning up the speculative coal that high prices had called forth.

Quite a volume was sacrificed down to 90 cents and $1; then with slow resumption of mining, prices swung back to normal and the market settled into an unusual dullness. There was practically nothing forwarded except on orders and there was no surplus to be absorbed. The Cambrias and Somersets again went out of the market, shippers finding their hands full to furnish contract requirements, and Aug. 15

saw quotations 5 cents @ 10 cents up and by Sept. 1 old prices had been withdrawn.

The contract basis for fair Clearfields was about $1.15 @ $1.20 and for Somersets $1.25 @ $1.30 or 5 cents higher than 1911 on all grades. The fancy brands of Cambria commanded $1.40 in most cases. Late in September all the popular coals were well sold up and from then on there was an advancing range of price on all the Pennsylvanias, varied only occasionally by an uneven demand.

New circular prices were announced June 1, with 25 cents advance on all sizes as compared with prices effective the same month in 1911, or 45 cents up compared with April, 1911. In addition to the increased contract price on broken announced Jan. 1, 1912, $5 instead of $4.75 alongside Boston, an advance in pea was effective November 1, making the new price $4.25 instead of $4 alongside Boston. In December another change was made by some of the companies shipping from New York, namely; a 15 cents higher water freight on anthracite barges, or 65 cents to Boston and Boston points rather than the 50 cents that had obtained for more than a dozen years.

The past 12 months have fulfilled certain predictions that were freely made; that a new high figure would be reached for the volume of business and hence also for the movement of freight. Railroad equipment had not kept step with the prospect and we had our great shortage of cars.

*Hampton Roads, Va.*—Hampton Roads has experienced the most unique year in its history. Over a million and a half tons more was dumped than during any preceding year. Altogether it has been a very prosperous year for Hampton Roads shippers; no failures are recorded in the coal industry and, on the other hand, new organizations have appeared in the field, and the older ones have broadened out and grown in proportion with the gradual increase of business. The value of the coal put afloat at these ports in 1912, estimating it at $2.60 a ton, which is a fair average price, is about twenty-nine millions of dollars.

Naturally the railroads have played their part in the prosperity of the port, and made numerous improvements, purchased equipment and locomotives, and improved in other directions in order to better serve the mines located on their respective lines. Both the Chesapeake & Ohio and the Norfolk & Western have begun work on new piers during the past year, which when completed will further the efficiency of Hampton Roads as a coaling port. It is still a matter of speculation as to what effect the completion of the Panama Canal will have on the export of coal from Hampton Roads, but it is the consensus of opinion that this port will very shortly be surpassed by few in volume of business handled and

by none in facilities and supply of high quality coal; these facts are alrea being more and more recognized by domestic as well as foreign trad and consumers.

*Ohio* (By B. J. W. Lehman).—The year 1912 was a fairly good one the Buckeye State both from a tonnage and a price standpoint. though the former was not as much as in 1910, which was the banner ye but is estimated to be about 10 per cent. over the output of 1911. T estimated production during the calendar year was in the neighborh of 33,340,000 tons.

Prices were more satisfactory from start to finish. While c operators and jobbers did not make a large profit on their investm during the year the returns were in the main much more satisfactory th in 1911. Price cutting was less prevalent during the past twelve mon and small operators and shippers were able to sell their coal with resorting to shaving quotations. The general tone of the market healthier and the year 1913 appears with a much better outlook.

The circular put into effect Sept. 1, 1911 by Hocking Valley operat prevailed during the greater part of the year. This circular was gener lived up to although during the summer months there was some discou ing from the list and some price cutting. But, generally speaking, operators who had a good grade of coal to sell could get the circular figu Domestic lump was quoted at $1.50 and 3/4-in. screened at $1. Mine-run was quoted at $1.15 and nut held at the same figure. market for the fine sizes such as nut, pea and slack and coarse sl was varied and depended exclusively upon local conditions. Some sn inflation occurred just previous to April 1, when large users of ste grades and many railroad companies stocked up to guard against em gencies. The two-year mining scale between operators and miners the central competitive district expired at that time and there considerable doubt of an early adjustment. Accordingly many of larger manufacturing plants laid in a goodly fuel supply and the lar railroad systems stocked thousands and even hundreds of thousand tons.

Outside of the suspension of a month in April when the wage s was signed there was practically no labor troubles during the y Generally speaking labor was plentiful and petty differences were no numerous as usual. One of the largest and most important troul was the strike ordered at the mine of the Hisylvania Coal Co. at Glou where the right to discharge for carelessness is involved. It is expec this strike will be settled in the near future.

*Buffalo, N. Y.*—The history of the coal trade throughout sho little incident during the early part of the year. Bituminous c

was still dull, as it had been for the whole of the past year or two. The consumer was entirely in control of prices, on account of the light consumption and the overproduction. Operators complained that they were not always able to make running expenses and some old members of the Allegheny Valley operating trade became so discouraged that they declared without hesitation that they could see no future before it. With the thin seams, so expensive to work, and the price always decidedly lower than that of Pittsburgh coal, it looked hopeless. There was always quite an amount of coal land for sale but there were no buyers among those who understood the conditions. All that saved the market and kept the mines running was the diversion of Pittsburgh coal to other points on the lakes. Moreover, higher freight rates kept the cheaply mined West Virginia coal out of the market.

The bituminous jobber was more hopeful. He had less at stake and he always insisted on a profit, though he often worked on a margin of 5 cents a ton. In order to make any showing it was necessary to handle a big tonnage and as a rule this was done. Buffalo covers a wide district, not only in this state and eastward, but through Canada, making shipments via Detroit as far west as London, Ont., and getting into Montreal in the other direction and competing with the coal from Nova Scotia. This railroad market does not cover the upper lakes, however. The rate of freight from the mines to the lakes is sufficiently above that from Pittsburgh that such trade is entirely cut off.

*Coal Movement in* 1912.—The following is a summary of the combined coal and coke movement over various railroads for the years 1911 and 1912 in short tons:

| | 1911. | 1912. |
|---|---|---|
| ...l & Ohio[1] | 35,321,771 | 40,525,280 |
| ...f. Roch. & P.[1 2] | 8,223,617 | 8,839,732 |
| ...f. & Susq.[2] | 1,951,256 | 1,810,930 |
| ...esp. & Ohio[2] | 16,488,024 | 17,296,185 |
| ...unt. & Br'd. T. M.[1 2] | 8,031,463 | 7,803,773 |
| ...Y. C. & H. R. R. R.[2] | 1,148,675 | 1,277,180 |
| ...& W. R. R.[1 2] | 8,108,738 | 8,396,018 |
| ...an. R. R.[1 2] | 20,954,839 | 24,112,787 |
| ...tts. & Lake Erie[2] | 65,015,701 | 70,117,880 |
| ...tts. Shs. & Nort[2] | 16,090,905 | 17,745,835 |
| ...uthern | 1,459,637 | 2,033,169 |
| ...rginian[2] | 4,826,794 | 4,062,363 |
| ...estern Md. | 2,817,201 | 3,584,292 |
| | 2,673,183 | 2,838,331 |

(1) Includes coal received from connecting lines.
(2) Includes company's coal.
(3) Does not include company's coal hauled free.

*Lake Coal Shipments.*—Coal passing through Sault Ste. Marie Canals for the full season for navigation was, in short tons:

| | 1911. | 1912. | Changes. |
|---|---|---|---|
| Anthracite | 2,060,209 | 2,142,485 | +82,276 |
| Bituminous | 13,272,667 | 12,789,109 | −483,557 |
| Total | 15,332,876 | 14,931,594 | −401,282 |

Total shipments of coal from Lake Erie ports for the Lake trade and steamship consumption for three seasons past, in short tons:

| | 1910. | 1911. | 1912. |
|---|---|---|---|
| Pittsburgh district | 11,911,900 | 10,611,941 | 11,300,000 |
| Ohio | 4,297,300 | 4,019,544 | 4,676,000 |
| West Virginia | 6,629,500 | 7,151,200 | 7,360,000 |
| Total | 22,838,700 | 21,782,685 | 23,336,000 |

In 1912 the Pittsburgh district furnished 48.4 per cent.; Ohio, 20 per cent. and West Virginia, 31.6 per cent. for the total.

# COPPER

The United States continues to produce more than one-half the world's output of copper and in 1912 was the source of about 55 per cent. of the total. The American refineries in 1912 produced[1] 1,581,920,287 lb. of all classes, excepting scrap, as compared with 1,431,938,338 lb. in 1911, 1,452,122,120 lb. in 1910, and 1,438,751,056 lb. in 1909, as shown in the table:

PRODUCTION OF COPPER IN UNITED STATES ACCORDING TO CLASS.
(In pounds.)

| Year. | Lake. | Electrolytic. (*d*) | Casting. (*d*) | Pig Copper. (*a*) | Total. |
|---|---|---|---|---|---|
| 1906 .... | 224,071,000 | (*c*)860,000,000 | 52,000,000 | 29,098,000 | (*c*)1,165,169,000 |
| 1907 .... | 220,317,041 | 854,441,000 | 47,957,890 | 30,032,000 | 1,152,747,890 |
| 1908 .... | 222,267,444 | 850,660,325 | 44,967,250 | 35,000,000 | 1,152,895,019 |
| 1909(*e*).. | 226,602,134 | 1,101,518,458 | 67,471,446 | 43,159,018 | 1,438,751,056 |
| 1910(*f*).. | 221,400,864 | 1,151,624,597 | (*g*)55,673,196 | 46,903,463 | (*g*)1,475,602,120 |
| 1911 .... | 216,412,867 | 1,156,627,311 | 22,977,534 | 35,920,626 | 1,431,938,338 |
| 1912 .... | 231,628,486 | 1,288,333,298 | 24,777,266 | 37,181,237 | 1,581,920,287 |

(*a*) Exported. (*b*) Estimated. (*c*) Partly estimated. (*d*) Included copper from scrap and junk. (*e*) The statistics for 1909 are officially communicated to us by the Copper Producers' Association, except that to its report of 34,123,446 lb. of casting copper we have added 33,348,000 lb. reported to us by the junk smelters. The term "Lake" copper is here used to designate all copper sold in the trade as such, regardless of the process by which it is refined. (*f*) Copper Producers' Association, through *Eng. and Min. Journ.*, May 6, 1911. (*g*) Includes 23,480,000 lb. from scrap.

The supply of crude copper received by refineries from United States smelters is computed from reports of the latter as follows: The smelteries of North America report in 1912, 1,554,719,217 lb. from scrap, native and foreign ores. Of this 45,735,673 lb. were refined in foreign refineries. The blister copper imported from outside of North America was 144,480,144 lb. The result is given in the following table for three years.[2]

SMELTERS' PRODUCTION.
(In pounds.)

| Source. | 1910. | 1911. | 1912. |
|---|---|---|---|
| North American ore | 1,284,339,246 | 1,284,932,019 | 1,489,168,562 |
| Foreign ore | 41,976,733 | 34,392,091 | 53,701,307 |
| Scrap | 10,962,099 | 18,529,547 | 11,949,348 |
| Totals | 1,337,278,078 | 1,337,853,657 | 1,554,719,217 |
| To foreign refiners | 33,855,800 | 32,413,440 | 45,735,673 |
| To American refiners | 1,303,422,278 | 1,305,440,217 | 1,508,983,544 |
| Blister copper imported | 146,185,104 | 146,422,851 | 144,480,144 |
| Total crude copper | 1,449,607,382 | 1,451,863,068 | 1,653,463,688 |

[1] *Eng. and Min. Journ.*, Jan. 11, 1913.
[2] *Eng. and Min. Journ.*, June 28, 1913.

The figures, as in the previous years, show a difference between the copper actually reported by the refineries and the larger amount of crude copper from the smelters. The difference is more than three times that for 1911 and allowing for the copper passing into blue stone as a by-product would be about 64,000,000 lb. An indefinite item not considered in these statistics is the stock locked up at the refineries and in the form of blister, etc., made from by-products at the refineries. It is claimed that this item may be as much as 30,000,000 lb. The stocks of copper at the smelters are not considered but are probably not much different from those at the end of 1911, which were small. Some uncertainty exists as to copper obtained from scrap both at refineries and smelters and as this may be considerable in amount, no deductions can really be drawn from the difference as reported. As to the copper tied up in anodes, electrolyte at refineries, etc., the amount is estimated to be at least 10 per cent. of the annual output. In the case of Michigan, the refinery and smeltery figures total the same, smelting and refining being one process.

A period of profitable prices in 1912 drew small quantities of copper from numerous new sources, making however a considerable aggregate. A large volume of new production stimulated by a rise in price was the feature at the beginning of 1912. At the close of the year, however, no such increase of production was expected. Inspiration will probably not produce before 1914; Chuquicamata not before 1915; of the producers in 1912 many such as Braden, Ray, Chino and Bingham, will have difficulty in increasing their productions on account of high costs partly due to conditions of the labor market. The crude copper smelter returns distributed over the separate States are the basis of the following table:

COPPER PRODUCTION OF THE UNITED STATES.
(In pounds.)

| | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|
| Alaska | 6,610,000 | 4,394,887 | 4,057,142 | 5,008,171 | 19,412,000 | 32,602,000 |
| Arizona | 256,866,761 | 290,167,795 | 292,042,829 | 299,606,971 | 300,578,816 | 357,952,962 |
| California | 34,398,823 | 36,890,353 | 53,357,451 | 45,793,894 | 36,806,762 | 31,069,029 |
| Colorado | 13,344,118 | 813,896,689 | 10,487,940 | 10,127,012 | 8,474,848 | 7,502,000 |
| Idaho | 11,471,101 | 8,749,559 | 7,770,010 | 6,216,461 | 3,745,210 | 5,964,542 |
| Michigan | 220,317,041 | 222,267,444 | 227,247,998 | 221,400,864 | 216,412,867 | 231,628,486 |
| Montana | 226,290,873 | 252,558,330 | 313,838,203 | 286,242,403 | 271,963,769 | 309,247,735 |
| Nevada | 1,462,450 | 12,174,269 | 51,835,309 | 63,877,500 | 65,385,728 | 82,530,608 |
| New Mexico | 8,652,873 | 8,523,652 | 5,134,506 | 3,632,351 | 1,518,288 | 27,488,912 |
| Utah | 68,333,115 | 70,978,952 | 100,438,543 | 125,042,381 | 138,336,905 | 131'673,803 |
| Wyoming | 2,919,137 | 2,384,356 | 89,654 | 180,861 | (b)130,499 | (c)1,121,109 |
| Southern States | 22,408,696 | 20,822,368 | 22,837,962 | 18,195,450 | 19,656,971 | 18,592,655 |
| Other States | 6,166,098 | 4,387,836 | 3,746,895 | 925,664 | 1,433,708 | 4,396,667 |
| Total | 879,241,766 | 948,196,490 | 1,105,336,326 | 1,086,249,983 | 1,083,856,371 | 1,241,762,508 |

(a) From *Eng. and Min. Journ.*, June 18, 1913. (b) U. S. Geol. Surv. (c) Washington alone; Wyoming under others; in 1912, 27570 lb.

The reports of American smelteries also give the following distribution for North America; incidentally the production of Chile and Peru as contributors are obtained by the same method in part.

SMELTERS' PRODUCTION OF COPPER IN NORTH AMERICA.
(In pounds.)

| Country. | 1910. | 1911. | 1912. |
|---|---|---|---|
| United States | 1,086,249,983 | 1,083,856,371 | 1,241,762,508 |
| Canada | 52,492,282 | 56,370,754 | 75,425,575 |
| Mexico | 137,797,217 | 136,430,331 | 162,295,545 |
| Cuba | 7,799,764 | 8,274,563 | 9,684,934 |
| Totals | 1,284,339,246 | 1,284,932,019 | 1,489,168,562 |

The production of electrolytic copper now amounts to about 80 per cent. of the total American production, and 70 to 75 per cent. of the world's production. The electrolytic copper produced by the several refineries is substantially uniform in quality.[1]

The standard specifications, approved Feb. 18, 1910, provide that all wirebar and cake copper shall have a purity of at least 99.9 per cent., silver being counted as copper, and an electrical resistivity not greater than 0.15535 international ohm per meter-gram at 20° C. The specifications of the American Society for Testing Materials adopted in 1911 are as follows:

(3) The copper in all shapes shall have a purity of at least 99.88 per cent. as determined by electrolytic assay, silver being counted as copper. All wirebars shall have a conductivity of at least 98.5 per cent. (annealed); all ingots and ingot bars shall have a conductivity of at least 97.5 per cent. (annealed), excepting only arsenical copper, which shall have a conductivity of not less than 90 per cent. (annealed). Cakes, slabs and billets shall come under the ingot classification, except when specified for electrical use at time of purchase, in which case wirebar classification shall apply. The annealed copper standard, or resistance of a meter-gram of standard annealed copper at 20° C., shall be considered as 0.15302 international ohm. The percentage conductivity for the purposes of this specification shall be calculated by dividing the resistivity of the annealed copper standard by the resistivity of the sample at 20° C.

(4) Wirebars, cakes, slabs and billets shall be substantially free from shrink holes, cold sets, pits, sloppy edges, concave tops and similar defects in set or casting. This clause shall not apply to ingots or ingot bars, in which case physical defects are of no consequence.

(5) Five per cent. variation in weight or 1/4 in. variation in any dimension from the refiner's published list or purchaser's specified size shall be considered good delivery; provided, however, that wirebars may vary in length 1 per cent. from the listed or specified length, and

[1] W. R. Ingalls, "How the Metals are Sold," *Eng. and Min. Journ.*, May 4, 1913.

cakes 3 per cent. from the listed or specified size in any dimension greater than 8 in. The weight of ingot and ingot-bar copper shall not exceed that specified by more than 10 per cent., but otherwise its variation is not important.

These specifications do not take into consideration the so-called casting copper used for the purpose of alloying with other metals to produce cast shapes.

A list of the important brands of copper in the American market is as follows:

| | |
|---|---|
| American Smelting and Refining Co. | P A |
| American Smelters Securities Co. | BER, BCW,[1] Tacoma |
| Anaconda Copper Mining Co. | M A |
| Arizona Copper Co. | A C C[1] |
| Balbach Smelting and Refining Co. | Bb[1] N B C |
| Calumet and Hecla Mining Co. | C & H M Co. |
| Copper Range | C R |
| Nichols Copper Co. | N L S, R M C |
| Phelps, Dodge and Co. | C[1] Q, P D C[1] |
| Quincy Mining Co. | Q M Co. |
| Raritan Copper Works | N E C |
| Tamarack and Osceola | T M Co. |
| Tennessee Copper Co. | T C C[1] |
| U. S. Metals Refining Co. | D R W |

*The Selling Agencies.*—A few of the producers sell directly their copper and handle no other copper. This is the practice of the Quincy, Miami, Mohawk and Wolverine companies; also of some of the smaller Lake companies. Other companies sell their own copper and also act as agents for other producers. Thus, the Calumet & Hecla sells the product of the other Lake companies in which it is a stockholder. The Anaconda Copper Mining Co., through the United Metals Selling Co., sells the Cananea, Copper Range and Highland Boy copper. Phelps, Dodge & Co. sells the Calumet & Arizona. The American Smelting and Refining Co. sells the Utah, Nevada, Ray, Chino and Tennessee copper. These concerns sell their outside copper on commission, the rate now being commonly 1 per cent. The American Metal Co. and L. Vogelstein & Co. act both as agents and as traders. The one large producer, Calumet & Hecla, and the five agencies mentioned sell about 80 per cent. of the total American copper product.

The production of copper from secondary sources in 1912 was equal to 17.5 per cent. of the smelter output of primary copper in the United States from all sources, or 22.3 per cent. of the primary copper smelted from domestic ores.[2] The secondary copper, excepting from brass, was 50,845 short tons in 1911 and 66,441 short tons in 1912. The remelted brass amounted to 80,370 tons in 1911, and 101,523 tons in 1912.

Efforts are being made to recover the copper wasted in tailings and dumps. The tailings in Michigan are the simplest of these problems

[1] Casting.
[2] *U. S. Geol. Surv.*

and it is estimated that 100,000,000 tons containing more than 10 lb. of copper can be retreated. The Anaconda slimes, probably 4,000,000 tons of 2 per cent. copper, and the tailings, 15,000,000 tons with 15 lb. of copper, may be treated by leaching, with which experiments are being made. The Bradley process, however, was abandoned after a large expenditure. Other companies have had economic wastes, but no cheap retreatment process is yet applicable.

*The "Porphyries."*—These low-grade properties are the large competitive factors in the copper production. When all these properties are producing up to capacity in a few years' time the annual production will approach 500,000,000 lb. The rate production from these properties at the end of 1912 may be estimated at 320,000,000 lb. per year. The following are the mill capacities, ore reserves and grade at the end of 1912:

| | Mill Capacity, Tons per Day. | Ore Reserves, Tons. | Grade Per Cent. Copper. |
|---|---|---|---|
| Chino | 6,000 | 94,000,000 | 1.81 |
| Inspiration | (a)5,000 | 45,000,000 | 2.0 |
| Miami | 3,000 | 20,800,000 | 2.48 |
| Nevada Consolidated | 8,000 | 38,853,551 | 1.67 |
| Ray Consolidated | 10,000 | 80,657,000 | 2.2 |
| Utah | 21,000 | 316,500,000 | 1.495 |

(a) Assumed.

The average cost of producing a pound of copper in the U. S. figures 8.96 cents.[1] The important part played by the precious metal recovery is shown in the following table:

| | Pounds Copper per Ton of Rock. | Cost per Ton. | Precious Metal Value per Pound Copper. | Net Cost per Pound of Copper. |
|---|---|---|---|---|
| Michigan mines | 20 1/4 | $1.86 | ..... | 9.19c. |
| Montana mines | 61 3/4 | 7.84 | 3.26c. | 9.44c. |
| Porphyries | 22 | 2.22 | 2.18c. | 7.98c. |
| Southwest sulphides | 74 1/2 | 8.00 | 1.17c. | 9.03c. |

In the case of two of the porphyries at least a slight increase in cost of producing copper was experienced in 1912; Miami reports 9.59 cents per pound and Nevada Consolidated 8.86 cents.

The average costs of copper for Lake Superior mines is computed for 1912 as 10.58 cents per lb.[2] For 7 years ending Jan. 1, 1913, the cost for this group of mines figures net 10.3 cents, and the ore yielded

[1] James Mc Naughton, Gen'l Mgr., Calumet and Hecla Company; address at Houghton, Mich.
[2] Heath Steele, *Eng. and Min. Journ.*, Vol. XCVI, p. 251.

20.4 lb. per ton average porphyries in the United States in 1912, treated ore yielding 20.93 lb. of copper per ton and produced copper for 10.23 cents per pound or net 8.83 cents. The costs for Utah Copper Co. over a 5-year period average 9.5 cents for operating. A miscellaneous group of mines in 1912 is estimated as having a cost of 12.16 for operating or 95.5 cents allowing credits. For a period of years the net cost figures 10.3 cents for this group. This record for a period of years for the three groups, after deducting all credits, gives the costs for about 2,000,000 short tons of copper produced, divided as follows: Lake Superior 650,000 tons; porphyries 350,000 tons; miscellaneous 1,000,000 tons. The porphyries have affected costs only a fraction of a cent per pound. In 1912 a 530,000-ton output was divided between the groups as follows: Lake 100,000; porphyry 125,000; miscellaneous 310,000 tons. Based on half the world's output, therefore, the cost appears to be about 9.6. It is doubtful whether the porphyry production now 60 per cent. of its capacity will be materially increased beyond the present capacity, and average costs in North America are not likely to be reduced.

About 65 per cent. of the total production of copper and brass is manufactured in Connecticut. The annual consumption of copper for manufacture at Detroit amounts to 53,000,000 lb., about one-third of this is shipped from refineries, one-third from Montana, and one-third from Michigan. The Interstate Commerce Commission ruled that on March 1, 1913, the difference in freight rate on refined copper from the latter points to Detroit be at least 10 cents less per 100 lb. than the corresponding rate to New York ports.

The reported use of copper in steel in order to prevent corrosion is thus far only a matter of experiment. It is certain, however, that there is less objection in the blast-furnace to cinder and products from the roasting of low-grade sulphur copper ores, which usually carry a small percentage of copper that finds its way into the iron and steel. It is estimated that the deliberate use of copper in steel to prevent corrosion, should experiments that are being made by some of the steel works prove this advisable, will add an annual consumption of copper amounting to 125,000,000 lb. This is on a basis of 0.2 per cent. copper in the steel.

*Copper Sulphate.*—The exports of copper sulphate were 7,421,439 lb. worth $319,255 in 1911, and 6,828,657 lb. worth $325,120 in 1912. Austria and Italy are large consumers. Prices in the United States were $5.50 per 100 lb.

The production of copper sulphate recovered as a by-product was 39,480,741 lb. in 1912, compared with 33,454,000 lb. in 1911, and 26,356,788 lb. in 1910.

*Consumption.*—Domestic deliveries totalled 819,665,948 lb. in 1912, as compared with 709,611,605 lb. in 1911, and 749,426,542 lb. in 1910. These are the figures of the Copper Producers Association as shown in detail in the following table:

| Month. | United States. | | | Visible Stocks. | | |
|---|---|---|---|---|---|---|
| | U. S. Refin'y Production. | Deliveries, Domestic. | Deliveries, for Export. | United States. | Europe. | Total. |
| Year, 1911 | 1,431,938,338 | 709,611,605 | 754,902,233 | ..... | ..... | ..... |
| I, 1912 | 119,337,753 | 62,343,901 | 80,167,904 | 89,454,695 | 158,323,200 | 247,777,895 |
| II | 116,035,809 | 56,228,368 | 63,148,096 | 66,280,643 | 154,851,200 | 221,131,843 |
| III | 125,694,601 | 67,487,466 | 58,779,566 | 62,939,988 | 141,142,400 | 204,082,387 |
| IV | 125,464,644 | 69,513,846 | 53,252,326 | 62,367,557 | 136,819,200 | 199,186,757 |
| V | 126,737,836 | 72,702,277 | 69,485,945 | 65,066,029 | 134,176,000 | 199,242,029 |
| VI | 122,315,240 | 66,146,229 | 61,449,650 | 49,615,643 | 117,801,600 | 167,417,244 |
| VII | 137,161,129 | 71,094,381 | 60,121,331 | 44,335,004 | 108,186,000 | 152,521,003 |
| VIII | 145,628,521 | 78,722,418 | 70,485,150 | 50,280,421 | 113,299,200 | 163,579,621 |
| IX | 140,089,819 | 63,460,810 | 60,264,796 | 46,701,374 | 113,568,000 | 160,269,374 |
| X | 145,405,453 | 84,104,734 | 47,621,342 | 46,701,374 | 107,408,000 | 170,473,587 |
| XI | 134,695,400 | 69,369,795 | 55,906,550 | 76,744,964 | 103,801,600 | 180,546,564 |
| XII | 143,354,042 | 58,491,723 | 65,713,796 | 86,164,059 | 96,947,200 | 183,111,259 |
| Year, 1912 | 1,581,920,287 | 819,665,948 | 746,396,452 | ..... | ..... | ..... |
| I, 1913 | ..... | ..... | ..... | 105,312,582 | 96,857,600 | 202,170,182 |

The factors influencing the copper situation are the increase of the visible supply offset by the decrease of the invisible supply in the hands of manufacturers. It is doubtful whether early in 1913 the amount of copper available for manufacture was really greater than in the middle of 1912. The total world's stock was the same in spite of an apparent increase as shown in the visible stocks. The stock at the beginning of 1913 may be equal to about 6 weeks' consumption, but in general the proportion between such stocks and consumption is now less than it was 3 years ago. The decrease in consumption therefore may be considered a temporary matter. Consumers are able to transfer temporarily at least the burden of carrying stocks to the producers. Labor difficulties at the mines in the United States undoubtedly had a limiting effect on production toward the close of 1912; it was then also that the supply of crude copper to American refineries reached a maximum. Consumption promises to outrun production in 1913.

In 1910 deliveries for export were 722,431,494 lb. and domestic deliveries 749,426,542 lb. The actual exports, though including some scrap, as given by the Dept. of Commerce, is found in the following table:

EXPORTS OF COPPER FROM THE UNITED STATES.(a)
Ore, matte and regulus stated in tons of 2240 lb. Ingots, etc., in pounds.

| Country. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|
| Ore, matte and regulus Exported to: | | | | | | |
| United Kingdom | 200 | 168 | 258 | ..... | ..... | ..... |
| Germany | 188 | 2 | ..... | ..... | ..... | ..... |
| Brit. North America | 82,016 | 55,367 | 50,571 | ..... | ..... | ..... |
| Mexico | 16,737 | 7,060 | 8,534 | ..... | ..... | ..... |
| Other countries | ..... | 552 | 520 | ..... | ..... | ..... |
| Total | 99,141 | 63,149 | 59,880 | 43,784 | 57,915 | 66,171 |
| Ingots and scrap (b) Exported to: | | | | | | |
| United Kingdom | 81,409,441 | 117,810,314 | 156,511,113 | 98,030,213 | 108,061,603 | 95,422,292 |
| Belgium | 3,822,551 | 5,560,366 | 6,016,861 | 7,176,258 | 5,125,C04 | 7,674,273 |
| France | 93,075,145 | 115,690,381 | 99,003,962 | 116,193,850 | 135,038,893 | 131,362,694 |
| Germany | 107,607,390 | 137,453,392 | 138,213,290 | 175,861,028 | 190,428,008 | 252,156,012 |
| Italy | 21,192,908 | 25,512,267 | 26,386,069 | 34,110,237 | 38,216,773 | 47,251,432 |
| Netherlands | 156,652,270 | 195,562,619 | 204,378,211 | 221,764,806 | 230,693,649 | 152,618,177 |
| Russia | 4,341,386 | 4,657,077 | 3,519,216 | 6,848,311 | 15,601,688 | 4,961,473 |
| Other Europe | 26,221,024 | 39,433,674 | 41,661,979 | 42,203,861 | 9,254,363 | 8,960,973 |
| Brit. North America | 3,747,410 | 3,977,142 | 6,790,410 | 5,628,487 | 8,931,582 | 30,302,856 |
| Mexico | 362,411 | 35,895 | 46,287 | ..... | ..... | ..... |
| China | 10,003,592 | 13,735,899 | ..... | ..... | ..... | ..... |
| Other countries | 493,873 | 2,447,101 | 319,328 | 499,492 | (c) 45,201,645 | (c)44,290,476 |
| Total | 508,929,401 | 661,876,127 | 682,846,726 | 708,316,543 | 786,553,208 | 775,000,658 |

(a) The exports of ore, matte and regulus are reported as gross weight, the copper contents not being stated. (b) Includes bars and plates. (c) Includes Austria-Hungary, 44,200,202 lb. and 38,558,151 lb. resp.

IMPORTS OF COPPER INTO THE UNITED STATES. (a)
(In pounds.)

| Country. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|
| Ore and matte Imported from: | | | | | | |
| Brit. North America | 12,803,069 | 11,187,297 | 9,689,829 | 10,034,806 | 12,919,644 | 28,930,073 |
| Mexico | 32,467,418 | 15,903,692 | 23,914,040 | 22,731,184 | 16,684,071 | 18,069,987 |
| South America | 8,790,621 | 13,025,614 | 20,987,197 | 19,425,233 | 15,305,335 | 26,749,545 |
| Other Countries | 5,657,679 | 16,365,340 | 26,496,327 | 33,033,752 | 23,717,628 | 31,122,098 |
| Total | 59,718,787 | 56,481,943 | 81,087,393 | 85,224,975 | 68,626,778 | 104,871,703 |
| Pig and scrap (b) Imported from: | | | | | | |
| United Kingdom | 25,706,852 | 5,434,435 | 26,527,574 | 18,649,727 | 9,004,461 | 1,404,118 |
| France | 606,662 | 168,506 | 490,191 | ..... | ..... | ..... |
| Germany | 6,814,338 | 1,451,370 | 1,045,647 | ..... | ..... | ..... |
| Other Europe | 5,616,261 | 13,359,117 | 27,379,175 | 25,411,393 | 28,042,257 | 31,670,095 |
| Brit. North America | 30,902,596 | 30,895,737 | 29,196,351 | 29,016,785 | 22,442,335 | 36,138,255 |
| Mexico | 76,741,532 | 43,742,993 | 76,119,724 | 84,008,907 | 97,115,574 | 124,742,193 |
| Cuba | 767,184 | 349,560 | 104,182 | ..... | ..... | ..... |
| West Indies (c) | 401,585 | 184,490 | 223,408 | ..... | ..... | ..... |
| Japan | 9,809,569 | 8,329,896 | 23,830,140 | 18,482,989 | 20,030,447 | 19,511,402 |
| Other countries | 35,534,688 | 58,308,040 | 55,797,329 | 83,640,995 | 89,345,686 | 91,903,529 |
| Total | 192,901,267 | 162,224,144 | 240,713,721 | 259,210,796 | 265,980,760 | 305,369,592 |

(a) The imports reported are the copper contents of ore matte and regulus. (b) Includes also bars ingots and plates. (c) Includes Bermuda. (d) as follows: Australia and Tasmania 24,700,333 lb; Peru 43,891,439 lb; Chile 8,627,421 lb.

The consumption of refined copper may be approximated as follows:

CONSUMPTION OF COPPER IN THE UNITED STATES. (a)

| Year. | Production. | Stock Jan. 1. | Imports. | Supply. | Exports. | Stock Dec. 31. | Consumption. |
|---|---|---|---|---|---|---|---|
| 1903... | 708,375,228 | 162,935,439 | 167,161,720 | 1,038,472,387 | 312,822,627 | 230,111,792 | 495,537,968 |
| 1904... | 817,715,005 | 230,111,792 | 182,292,205 | 1,230,119,002 | 555,638,552 | 208,376,672 | 466,103,778 |
| 1905... | 875,241,741 | 208,376,672 | 210,724,685 | 1,294,343,098 | 548,772,403 | 132,587,496 | 612,983,199 |
| 1906... | 917,620,000 | 132,587,496 | 225,593,281 | 1,275,800,777 | 467,839,041 | 139,385,400 | 668,576,336 |
| 1907... | 1,152,747,890 | 9,000,000 | 5,000,000 | 1,166,747,890 | 508,929,401 | 120,000,000 | 537,818,489 |
| 1908... | 1,152,895,019 | 120,000,000 | ..... | 1,272,895,019 | 661,876,127 | 122,357,266 | 488,661,623 |
| 1909... | 1,405,403,056 | 122,357,266 | ..... | 1,527,760,322 | 682,846,726 | 141,766,111 | 703,147,485 |
| 1910... | 1,452,122,120 | 141,766,111 | ..... | 1,593,888,231 | 708,316,543 | 122,030,195 | 763,541,493 |
| 1911... | 1,431,938,338 | 122,030,195 | ..... | 1,555,968,533 | 786,553,208 | 89,454,695 | 677,960,630 |
| 1912... | 1,581,920,287 | 89,454,695 | ..... | 1,671,374,982 | 775,000,658 | 105,312,582 | 791,061,742 |

(a) The statistics in the above table up to 1906 inclusive are computed in the old way, namely, on the basis of the production of blister copper and the imports of copper in all forms. The stock on hand at the beginning and end of the year includes not only refined copper, but also the crude copper in transit and in process of refining. The statistics since 1906 are computed on the new and more accurate method described in *Eng. and Min. Journ.*, July 25, 1908. Briefly, in this method the basis is production of refined copper, stock of copper in final marketable form and imports of refined copper. This change in method explains the erratic appearance of the figures for 1907 as compared with those of 1906.

LAKE COPPER SALES. (a)

| Company. | 1911. | | | 1912. | | |
|---|---|---|---|---|---|---|
| | Pounds. | Amount. | Average. | Pounds. | Amount. | Average. |
| Ahmeek | 14,336,750 | $1,832,892 | 12.78 | 15,950,492 | 2,649,489 | 16.61 |
| Allouez | 4,482,267 | 547,719 | 12.822 | 4,367,964 | 728,043 | 16.668 |
| Baltic | 15,370,449 | 1,927,036 | 12.54 | 13,373,961 | 2,161,000 | 16.16 |
| Centennial | 1,393,830 | 178,997 | 12.842 | 1,196,255 | 203,153 | 16.982 |
| Champion | 15,639,426 | 1,960,758 | 12.54 | 17,225,508 | 2,783,000 | 16.16 |
| Franklin | 1,200,789 | 150,300 | 12.516 | 1,710,651 | 287,285 | 16.795 |
| Isle Royale | 6,134,643 | 759,279 | 12.38 | 7,782,078 | 1,296,780 | 16.66 |
| La Salle | 211,398 | 26,851 | 12.70 | ..... | ..... | ..... |
| Mohawk | 12,091,056 | 1,527,108 | 12.63 | 11,995,598 | 1,928,900 | 16.08 |
| Osceola Cons. | 17,470,124 | 2,222,776 | 12.72 | 17,175,066 | 2,855,658 | 16.63 |
| Quincy | 22,252,943 | 2,831,799 | 12.725 | 20,634,800 | 3,351,360 | 16.24 |
| Superior | 3,103,049 | 392,621 | 12.652 | 2,927,182 | 497,552 | 16.997 |
| Tamarack | 7,162,872 | 910,111 | 12.71 | 7,298,205 | 1,208,659 | 16.56 |
| Trimountain | 6,120,417 | 767,332 | 12.54 | 6,980,713 | 1,128,000 | 16.16 |
| Victoria | 1,030,993 | 126,498 | 12.27 | 1,002,924 | 165,538 | 16.5 |
| Total | ..... | ..... | ..... | ..... | ..... | ..... |

(a) Not complete; see production table.

The world's production of copper, as in the table, is chiefly from figures by the *Eng. and Min. Journ.*; others are from Henry R. Merton & Co. In all cases the production from domestic raw products and ore only are included and for the reason that in a few cases some of these may have been exported without recording them, the figures may be low. Estimates made by H. R. Merton total 871,920 long tons in 1911, and 1,004,485 tons in 1912. The estimates by Aaron Hirsch and Sohn, Halberstadt, Germany, are 857,150 long tons, 869,370 long tons and 1,008,290 in the years 1910, 1911 and 1912, respectively. The *Metallgesellschaft*, Frankfurt a. M., estimates 887,900 metric tons, 893,400

and 1,019,800 tons in the corresponding years. The latter firm uses a production figure for the United States of 592,400 tons in 1912, thus crediting this country with 58.1 per cent. of the world's production. The consumption in the United States is given by the same firm as 36.5 per cent. of the world's consumption, Europe consuming 61.3 per cent. and producing 19.3 per cent. of the world's production.

THE WORLD'S COPPER PRODUCTION.

(In metric tons.)

| Country. | 1903. | 1904. | 1905. | 1906. | 1907. | 1908. | 1909. | 1910. (*h*) | 1911. | 1912. |
|---|---|---|---|---|---|---|---|---|---|---|
| Africa (*a*) Cape Co. | 4,704 | 5,563 | 5,105 | 4,003 | 4,298 | 4,550 | 4,720 | 7,016 | 17,252 | 16,63[3] |
| Africa (*a*) Namaqua | 610 | 2,337 | 2,337 | 2,642 | 2,540 | 2,440 | 2,337 | | | |
| Africa (*a*) Other | ..... | ..... | ..... | ..... | ..... | ..... | 8,128 | 8,433 | ..... | ..... |
| Argentina (*a*) | 137 | 157 | 157 | 107 | 224 | 226 | 610 | 305 | 1,036 | 335 |
| Australasia (*a*) | 29,464 | 34,706 | 34,483 | 36,830 | 41,910 | 40,123 | 34,952 | 40,962 | 42,512 | 47,774 |
| Austria-Hungary (*a*) | 1,407 | 1,473 | 1,346 | 1,458 | 1,062 | 3,877 | 6,218 | 2,276 | 2,566 | 4,02[7] |
| Bolivia (*a*) | 2,032 | 2,032 | 2,032 | 2,540 | 21,035 | 2,540 | 2,032 | 2,540 | (*d*) 2,950 | *d*) 4,681 |
| Canada (*d*) | 19,637 | 19,490 | 21,595 | 19,110 | 2,540 | 24,376 | 21,626 | 23,810 | 25,570 | 34,213 |
| Chile (*d*) | 29,923 | 31,025 | 29,126 | 25,829 | 28,863 | 42,097 | 42,726 | 38,346 | 33,088 | 39,204 |
| Cuba (*d*) | ..... | ..... | ..... | 1,384 | 1,388 | 2,966 | 3,006 | 3,538 | 3,753 | 4,393 |
| Germany—total (*a*) | 32,214 | 30,262 | 22,492 | 20,665 | 20,818 | 20,523 | 32,815 | 25,105 | 22,363 | 24,304 |
| (Mansfeld) (*a*) | (19,810) | (19,578) | (19,878) | (18,085) | (17,343) | (18,000) | (19,015) | (20,275) | ..... | ..... |
| Italy (*a*) | 3,150 | 3,388 | 2,997 | 2,911 | 3,353 | 3,022 | 2,769 | 3,272 | 2,642 | 2,337 |
| Japan (*f*) | 31,861 | 33,187 | 35,944 | 36,963 | 40,183 | 41,399 | 42,987 | 50,703 | *d*) 52,303 | *d*) 62,486 |
| Mexico—total (*d*) | 46,040 | 51,759 | 65,449 | 61,615 | 57,491 | 38,190 | 57,230 | 62,504 | 61,884 | 73,6[1]7 |
| (Boleo) (*a*) | (10,480) | (11,120) | (10,341) | (11,002) | (11,506) | (12,600) | (12,426) | (13,003) | ..... | ..... |
| Newfoundland (*a*) | 2,753 | 2,235 | 2,316 | 2,332 | 1,758 | 1,453 | 1,402 | 1,097 | 1,174 | 549 |
| Norway (*a*) | 6,010 | 5,502 | 6,406 | 6,218 | 7,122 | 9,337 | 9,226 | 10,592 | 9,576 | 11,156 |
| Peru (*e*) | 9,497 | 9,504 | 12,213 | 13,474 | 20,681 | 15,240 | 16,257 | 27,375 | 28,500 | *f*) 26,483 |
| Russia (*c*) | 9,232 | 9,835 | 9,515 | 9,296 | 15,930 | 17,718 | 18,035 | 22,670 | 25,747 | 33,550 |
| Spain-Portugal (*a*) | 50,536 | 47,788 | 45,527 | 50,109 | 50,470 | 53,425 | 53,023 | 51,080 | 51,748 | 59,876 |
| Rio Tinto (*a*) | 36,382 | 34,016 | 32,795 | 34,642 | 32,833 | 35,517 | 35,938 | (34,114) | (35,100) | ..... |
| Tharsis (*a*) | 6,421 | 5,710 | 4,415 | 4,816 | 4,206 | 4,500 | 4,425 | (3,551) | (3,450) | ..... |
| Mason & Barry (*a*) | 2,469 | 2,997 | 2,764 | 2,504 | 2,662 | 2,804 | 2,403 | (3,003) | (2,972) | ..... |
| Sevilla (*a*) | 1,123 | 1,351 | 1,300 | 2,073 | 2,337 | 2,196 | 1,849 | (1,656) | (1,558) | ..... |
| Sweden (*c*) | 776 | 533 | 1,385 | 1,209 | 1,577 | 2,808 | 2,032 | 2,032 | 2,032 | (*a*) 1,524 |
| Turkey (*a*) | 1,422 | 965 | 711 | 432 | 1,270 | 1,068 | 813 | 610 | 1,016 | 508 |
| United Kingdom (*g*) | 545 | 501 | 727 | 762 | 677 | 588 | 442 | 508 | 405 | 405 |
| United States (*d*) | 312,631 | 400,998 | 397,069 | 416,343 | 398,930 | 430,399 | 501,372 | 492,720 | 491,634 | 563,260 |
| Total | 630,590 | 693,240 | 698,931 | 715,510 | 724,120 | 758,065 | 854,758 | 877,494 | 879,751 | 1,011,312 |

(*a*) As reported by Henry R. Merton & Co., Ltd., of London. (*b*) As reported by Henry R. Merton & Co., previous to 1905, subsequently as reported by the *Eng. and Min. Journ.* (*c*) As officially reported except for 1909, for which year the figure of Henry R. Merton & Co. is used. (*d*) As reported by the *Eng. and Min. Journ.* (*e*) As reported by Henry R. Merton & Co. for 1900–1902, as officially reported 1903–1907, as per Henry R. Merton & Co. for 1908 and 1909. (*f*) As officially reported. (*g*) As officially reported, 1900–1905; subsequently as per Henry R. Merton & Co. (*h*) Henry R. Merton & Co., through *Eng. and Min. Journ.*

WORLD'S PRODUCTION OF COPPER. (*a*)

| Year. | Metric Tons. | Short Tons. | Year. | Metric Tons. | Short Tons. | Year. | Metric Tons. | Short Tons. |
|---|---|---|---|---|---|---|---|---|
| 1881 | 166,065 | 183,093 | 1892 | 309,113 | 340,808 | 1903 | 630,590 | 694,910 |
| 1882 | 184,620 | 203,550 | 1893 | 310,704 | 342,562 | 1904 | 693,240 | 764,758 |
| 1883 | 202,697 | 223,481 | 1894 | 330,075 | 363,920 | 1905 | 698,931 | 770,221 |
| 1884 | 223,884 | 246,840 | 1895 | 339,994 | 374,856 | 1906 | 715,510 | 788,492 |
| 1885 | 229,315 | 252,828 | 1896 | 384,493 | 423,917 | 1907 | 724,120 | 798,205 |
| 1886 | 220,669 | 243,295 | 1897 | 412,818 | 455,147 | 1908 | 758,065 | 835,623 |
| 1887 | 226,492 | 249,716 | 1898 | 441,282 | 486,529 | 1909 | 854,758 | 942,408 |
| 1888 | 262,285 | 281,179 | 1899 | 476,194 | 525,021 | 1910 | 877,494 | 966,998 |
| 1889 | 265,516 | 292,741 | 1900 | 491,435 | 541,561 | 1911 | 879,751 | 969,750 |
| 1890 | 274,065 | 302,166 | 1901 | 529,508 | 583,517 | 1912 | 1,011,312 | 1,114,769 |
| 1891 | 280,138 | 308,862 | 1902 | 542,606 | 597,951 | | | |

(*a*) The statisticsfor 1881–91 are as reported by Henry R. Merton & Co.: 1892–1910 as per THE MINERAL INDUSTRY.

## The Copper Market in 1912

The year 1912 witnessed a great revival in the copper market. This was due primarily to the increase in consumption, both in Europe and in the United States. In Europe, there had been a steady increase in consumption ever since 1905. The best authorities estimate the European consumption to have been 404,800 metric tons in 1906; 411,600 in 1907; 480,500 in 1908; 452,600 in 1909; 541,100 in 1910; 606,300 in 1911. In the United States, the consumption had reached about 305,000 metric tons in 1906, but in consequence of the panic in 1907 fell off to 229,000 metric tons in 1907. It was only 211,200 in 1908. In 1909 it advanced to 323,300 tons; in 1910 to 342,000; and in 1911 to 326,400.

The world's stocks of copper, which had steadily risen from 1906 to 1907, were considerably reduced by the increased European consumption during 1910 and 1911, and at the end of 1911 had receded to about 102,000 metric tons, being approximately 1 month's supply. The world's production had changed but little since 1908, having been about 849,200 metric tons in 1909; 882,350 in 1910, and 887,088 in 1911.

The low price prevailing during these years, the unwillingness of the largest mines to force production upon an overstocked market, and the slowness with which the new porphyry mines could be brought to the point of large output, all contributed to keep the production from increasing more rapidly. During the first 9 months of 1911, the market had remained depressed and the price fluctuated around 12 1/2 cents, but in the last quarter, deliveries both in Europe and the United States increased largely and the market became buoyant, the price advancing by the end of the year to about 14 cents. At that time it looked very doubtful whether this price could be maintained for long, as an increased production from the porphyry mines of about 12,500,000 lb. per month was due to make its appearance early in 1912, and the European consumption had been so good for the previous years that a recession was expectted. But as usual, the unexpected happened. In the first place, the increased production did not put in its appearance in the form of refined copper available for delivery to manufacturers until the second half of the year. In the second place, the European consumption maintained itself; and, in addition to these two developments, a great revival in the American consumption occurred. What with the small stocks on hand at the beginning of the year, the conjuncture of these favorable factors made the market buoyant and strong and gave the copper producers a good year after the 5 previous bad ones. The average price of electrolytic copper at New York for 1912 was about 16 3/8 cents., compared with about 12 3/8 cents in 1911.

Ever since the panic year of 1907, the large stocks of copper in first hands and in warehouse caused consumers to adopt a hand-to-mouth policy and to keep their own supplies down to a minimum. This had the double effect of throwing an extraordinary burden upon the producers, and also of causing them, in dull moments, to become unduly nervous on account of the few sales upon their books. In 1912 the American consumers, of course, were the first to feel the great revival in the demand, which the repression of the after-panic years had prepared. They also saw that the visible supply was down to a very low figure. In consequence, they changed their policy and became large buyers for deliveries months ahead. This it was that gave the market its remarkable stability in 1912, and prevented great recessions in prices during the intervals between buying movements. In previous years, the producers at such times had pressed their copper upon an unwilling market. In 1912, with goodly quantities booked ahead and the prospect of a continuance of heavy consumption assured by the bountiful harvests, they faced these periods of dullness with equanimity.

The year opened with a very heavy buying movement, for deliveries over January and February, at about 14 1/2 cents, delivered at buyers' works. This was induced by the expectation of a continued decrease in the American stocks on hand.

By the end of January, one of the leading American sellers decided to meet the market and cut the price to 14 cents. The American mills for the first time in years felt impelled to buy ahead in a large way. Under heavy transactions prices advanced steadily to 14 1/2 cents, and continued to rise rapidly until March, at the end of which month 15 7/8 cents had been reached.

In April, a lull set in. At this time sales were made by second hands at less than the prices asked by the principal producers, being in the nature of realizations of speculative profits, but these were readily absorbed.

The London standard market declined under similar realizing sales there, and fell below the parity of the American market for electrolytic, which caused large quantities of refined copper to move out of the English warehouses into the hands of consumers. The London standard market then turned upward again; both European and American buyers
e into the market for their June and July supplies, and when strikes
out at the refineries, it began to look as though the requirements
ated buyers might not easily be met. The buying became heavy
ices advanced rapidly to 16 3/4 cents.
the beginning of June it appeared that during May European
ad been diminished by about 15,000,000 lb., American stocks by

about the same amount and that the total visible supply was becoming small. Tremendous orders were placed, covering deliveries as far ahead as September at advancing prices, and 17 3/4 cents was reached. Stocks in this country had dwindled to only 45,000,000 lb., equivalent to only 10 days' supply.

AVERAGE MONTHLY PRICES OF COPPER MANUFACTURES.
(In cents per pound.)

| | 1911. | | 1912. | |
|---|---|---|---|---|
| | Copper Wire. | Sheet Copper. | Copper Wire. | Sheet Copper. |
| Jan. | 14.06 | 18.50 | 15.75 | 19.50 |
| Feb. | 13.50 | 18.50 | 15.25 | 19.50 |
| Mar. | 13.25 | 18.50 | 16.03 | 20.30 |
| Apr. | 13.75 | 18.50 | 17.06 | 21.50 |
| May. | 13.75 | 18.50 | 17.30 | 21.63 |
| June. | 13.75 | 18.50 | 18.68 | 22.50 |
| July. | 13.90 | 18.50 | 19.13 | 22.50 |
| Aug. | 13.81 | 18.50 | 19.13 | 22.75 |
| Sept. | 13.75 | 18.50 | 19.13 | 23.50 |
| Oct. | 13.50 | 18.50 | 19.13 | 23.50 |
| Nov. | 13.75 | 18.63 | 19.13 | 23.50 |
| Dec. | 14.94 | 19.13 | 19.13 | 23.50 |
| Year. | 13.81 | 18.56 | 17.96 | 22.02 |

AVERAGE PRICE OF STANDARD COPPER (G. M. B.'s) IN LONDON. (a)
(In pounds sterling per ton of 2240 lb.)

| Year. | Jan. | Feb. | Mar. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1903. | 53.52 | 57.34 | 63.85 | 61.72 | 61.73 | 57.30 | 56.64 | 58.44 | 56.82 | 55.60 | 56.30 | 56.36 | 57.97 |
| 1904. | 57.500 | 56.500 | 57.321 | 58.247 | 57.321 | 56.398 | 57.256 | 59.952 | 57.645 | 60.012 | 65.085 | 66.375 | 58.884 |
| 1905. | 68.262 | 67.963 | 68.174 | 67.017 | 64.875 | 65.881 | 66.887 | 69.830 | 69.667 | 71.406 | 74.727 | 78.993 | 69.465 |
| 1906. | 78.869 | 78.147 | 81.111 | 84.793 | 84.867 | 83.994 | 81.167 | 83.864 | 87.831 | 97.269 | 100.270 | 105.226 | 87.282 |
| 1907. | 106.739 | 107.356 | 106.594 | 98.625 | 102.375 | 97.272 | 95.016 | 79.679 | 68.375 | 60.717 | 61.226 | 60.113 | 87.007 |
| 1908. | 62.386 | 58.786 | 58.761 | 58.331 | 57.387 | 57.842 | 57.989 | 60.500 | 60.338 | 60.139 | 63.417 | 62.943 | 59.902 |
| 1909. | 61.198 | 57.688 | 56.231 | 57.363 | 59.338 | 59.627 | 58.556 | 59.393 | 59.021 | 57.551 | 58.917 | 59.906 | 58.732 |
| 1910. | 60.923 | 59.388 | 59.214 | 57.238 | 56.313 | 55.310 | 54.194 | 55.733 | 55.207 | 56.722 | 57.634 | 56.009 | 57.054 |
| 1911. | 55.604 | 54.970 | 54.704 | 54.035 | 54.313 | 56.368 | 56.670 | 56.264 | 55.253 | 55.176 | 57.253 | 62.063 | 55.973 |
| 1912. | 62.760 | 62.893 | 65.884 | 70.294 | 72.352 | 78.259 | 76.636 | 78.670 | 78.762 | 76.389 | 76.890 | 75.516 | 72.942 |

AVERAGE PRICE OF LAKE COPPER PER POUND IN NEW YORK. (a)

| Year | Jan. | Feb. | Mar. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. |
| 1903. | 12.361 | 12.901 | 14.752 | 14.642 | 14.618 | 14.212 | 13.341 | 13.159 | 13.345 | 12.954 | 12.813 | 12.084 | 13.417 |
| 1904. | 12.533 | 12.245 | 12.551 | 13.120 | 13.000 | 12.399 | 12.505 | 12.468 | 12.620 | 13.118 | 14.456 | 14.849 | 12.990 |
| 1905. | 15.128 | 15.136 | 15.250 | 15.045 | 14.820 | 14.813 | 15.005 | 15.725 | 15.978 | 16.332 | 16.758 | 18.398 | 15.699 |
| 1906. | 18.419 | 18.116 | 18.641 | 18.688 | 18.724 | 18.719 | 18.585 | 18.706 | 19.328 | 21.722 | 22.398 | 23.350 | 19.616 |
| 1907. | 24.825 | 25.236 | 25.560 | 25.260 | 25.072 | 24.140 | 21.923 | 19.255 | 16.047 | 13.551 | 13.870 | 13.393 | 20.661 |
| 1908. | 13.901 | 13.098 | 12.875 | 12.928 | 12.788 | 12.877 | 12.933 | 13.639 | 13.600 | 13.646 | 14.386 | 14.411 | 13.424 |
| 1909. | 14.280 | 13.295 | 12.826 | 12.938 | 13.238 | 13.548 | 13.363 | 13.296 | 13.210 | 13.030 | 13.354 | 13.647 | 13.335 |
| 1910. | 13.870 | 13.719 | 13.586 | 13.091 | 12.885 | 12.798 | 12.570 | 12.715 | 12.668 | 12.788 | 12.914 | 12.863 | 13.039 |
| 1911. | 12.680 | 12.611 | 12.447 | 12.275 | 12.214 | 12.611 | 12.720 | 12.634 | 12.508 | 12.370 | 12.769 | 13.768 | 12.634 |
| 1912. | 14.337 | 14.329 | 14.868 | 15.930 | 16.245 | 17.443 | 17.353 | 17.644 | 17.698 | 17.661 | 17.617 | 17.600 | 16.560 |

AVERAGE PRICE OF ELECTROLYTIC COPPER PER POUND IN NEW YORK. (a)

| Year | Jan. | Feb. | Mar. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. |
| 1903. | 12.159 | 12.778 | 14.416 | 14.454 | 14.435 | 13.942 | 13.094 | 12.962 | 13.205 | 12.801 | 12.617 | 11.952 | 13.235 |
| 1904. | 12.410 | 12.063 | 12.299 | 12.923 | 12.758 | 12.269 | 12.380 | 12.343 | 12.495 | 12.993 | 14.284 | 14.661 | 12.823 |
| 1905. | 15.008 | 15.008 | 15.125 | 14.920 | 14.627 | 14.673 | 14.888 | 15.664 | 15.965 | 16.279 | 16.599 | 18.328 | 15.590 |
| 1906. | 18.310 | 17.869 | 18.361 | 18.375 | 18.457 | 18.442 | 18.190 | 18.380 | 19.033 | 21.203 | 21.833 | 22.885 | 19.278 |
| 1907. | 24.404 | 24.869 | 25.065 | 24.224 | 24.048 | 22.665 | 21.130 | 18.356 | 15.565 | 13.169 | 13.391 | 13.163 | 20.004 |
| 1908. | 13.726 | 12.905 | 12.704 | 12.743 | 12.598 | 12.675 | 12.702 | 13.462 | 13.388 | 13.354 | 14.130 | 14.111 | 13.208 |
| 1909. | 13.893 | 12.949 | 12.387 | 12.563 | 12.893 | 13.214 | 12.880 | 13.007 | 12.870 | 12.700 | 13.125 | 13.298 | 12.982 |
| 1910. | 13.620 | 13.332 | 13.255 | 12.733 | 12.550 | 12.404 | 12.215 | 12.490 | 12.379 | 12.553 | 12.742 | 12.581 | 12.738 |
| 1911. | 12.295 | 12.256 | 12.139 | 12.019 | 11.989 | 12.385 | 12.463 | 13.405 | 12.201 | 12.189 | 12.616 | 13.552 | 12.376 |
| 1912. | 14.094 | 14.084 | 14.698 | 15.741 | 16.031 | 17.234 | 17.190 | 17.498 | 17.508 | 17.314 | 17.326 | 17.376 | 16.341 |

(a) From *Eng. and Min. Journ.*

There had been a large amount of speculation in the London standard market and heavy bull accounts had accumulated all the way up to £80 10s. Early in July, when the market stopped rising, there was a scramble to take profits, which quickly brought standard three months' copper down about £6. Of course, this sudden decline scared off the buyers of refined copper, who had not yet entirely covered their early requirements. The large producers, having practically sold out for 2 months ahead, remained quiescent. When some little demand again appeared, it was filled by dealers who arbitraged in standard and could therefore sell over 1 cent below the producers' price of 17 3/4 cents. By the middle of the month, the London market had absorbed the realization sales and began to pick up, and the quantities of refined copper held outside of the big producers had been disposed of. This led to a sharp reaction upward and by the end of July, 17 3/4 cents was again the ruling price.

August was a dull month. Large orders for September shipment were forthcoming from Europe and could be filled only by the leading sellers. It was not until the end of September, when strikes at the mines of the Utah Copper Co. again caused apprehension of an inadequate supply, that the European consumer came forward and placed orders for October and November shipment.

The breaking out of the Balkan war in October caused a sharp break in standard to £75 for 3 months, and again brought London standard below the parity of electrolytic in New York. The large producers, being satisfied that their copper would be required, continued to hold for 17 3/4 cents right through November and December, and left the market to the arbitrageurs and the smaller sellers, who sold their copper at around 17 1/2, delivered; the business was principally for export and for early

nent. American buyers held aloof. In the second half of the year,

·rease in production from the porphyry mines made its appearance

ks in America began to increase. Those in Europe, however,

continued to decrease, and the year closed with about 25,000,000 lb. less in public stocks than at its beginning.

During the last quarter of 1912, consumers the world over had again begun to reduce their own holdings, and thus the invisible supply at the end of 1912 is, no doubt, smaller than at the commencement of that year. They also had relapsed into a hand-to-mouth policy. Considering these facts, it is evident that as a whole the statistical position at the close of the year was still very good.

## Copper Mining in the United States

Utah's failure to show an increase was undoubtedly due to the strikes, which, among other things, put the Tooele smeltery out of commission during part of the year. Nevada's big increase may be attributed largely to the inauguration of production by the Mason Valley and Giroux companies. Copper production in California halted because certain important producers continued idle, owing to smoke injunctions, etc. The great increase in production in New Mexico was due to the Chino, but resumption of smelting by the Santa Fé Copper Co. added a little to the total. In Arizona, the Ray and Miami companies both made very large outputs. The older companies did about the same as in 1911. Alaska's great output came chiefly from the Bonanza mine, in the Copper River district.

*Alaska* (A. H. Brooks).[1]—The increased copper production of 1912, compared with 1911, is to be credited to the Chitina and Prince William Sound districts. The rise in the price of copper led to much prospecting and deadwork in these as well as in other districts.

The Jumbo and Rush & Brown mines were the only large shippers of copper ore in the Ketchikan district. It appears that the Mount Andrew mine was idle for most of the year, but plans were formulated for systematic development. Developments were continued on the It, the Red Wing, the Vittory, and the Lhote & Sanford properties, and steps were taken looking to the reopening of the Copper Mountain mine. Some work was also done on a copper-bearing vein at Sum Dum, in the Juneau district.

The Kennicott-Bonanza mine is the only one in the Kotsina-Chitina district from which shipments were made in 1912, but a large amount of development work was done on other properties. The concentrator installed in 1911 at the Bonanza mine was operated during 1912. At the east end of the field, work was continued on the Mother Lode, Nikolai,

[1] *Eng. and Min. Journ.*, Jan. 11, 1913, from preliminary report to the Director of the U. S. Geol. Surv.

and Westover properties and also on a property located on an island in the Kennicott Glacier. Prospecting and developing were especially active in the vicinity of Kuskulana River. Here the largest operations were those of the Great Northern Development Co., which completed about 5000 ft. of development work. The Alaska Consolidated Copper Co. carried on development work on Nugget Creek and on the Rarus group of claims. The Alaska United Copper Exploration Co. continued work on the Blackburn group of claims, on Porcupine Creek.

On Prince William Sound shipments were made by the Ellamar Mining Co., the Threeman Mining Co., the Landlocked Bay Copper Mining Co., and the Beatson Copper Co., on Latouche Island. In addition to productive properties, there were a large number of claims on which development work was carried on, some of which give promise of soon reaching a shipping stage. A notable advance was that made on the Solomon Gulch property, near Valdez, where a force of men was engaged in 1912 in opening a chalcopyrite ore-body.

But little advance was made in copper prospecting in those inland districts which are far from transportation. About twenty-five men are said to be carrying on prospecting and assessment work in the White River region, and there are also some in the Nabesna district. Prospectors report the finding of copper ore on Sheep Mountain, in the Matanuska Valley. Some copper ore was also found on a tributary of the McLaren River, in the headwater region of the Susitna. A little development work was also continued on the copper prospects of the Iliamna region, in southwestern Alaska.

The Kennecott Mines Co. has more than paid back its capital this year; this company is capitalized at $2,500,000. The Bonanza mine doubtless contained the highest-grade copper ore-body of its size so far discovered in the world. Since April, 1911, it has shipped about 29,000 tons, containing approximately 40,000,000 pounds of copper, an average tenor of about 70 per cent. copper. In 1912 dividends of $3,000,000 were paid. The Bonanza mine is now opened to a depth of over 400 ft.

*Arizona.*—The production was the largest of any state in 1912 or in any previous year. Arizona, however, in total production still ranks third, Montana being first and Michigan second.

(By James Douglas).[1]—Arizona responded to the higher market price for copper prevailing in 1912 by notably increasing her output, both from the older sources and from the mills of the newly developed so-called porphyry mines. No discoveries of any note were made, but on the other hand, all the older properties increased instead of depleted their reserves, and introduced improvements in both their mining and metal-

[1] President, Phelps, Dodge & Co.

lurgical departments, which will enable them to handle lower-grade ores when necessity forces that inevitable calamity upon them.

The Copper Queen still retains its preëminence with an output of 82,138,000 lb. Its neighbor, the consolidated Calumet & Arizona and Superior & Pittsburgh, comes next in the list, followed by the Old Dominion, the United Verde and the Arizona Copper Co. The only new works started in 1912 were those of the American Smelting & Refining Co., at Hayden.

A feature of interest in the Warren district was the finding of larger quantities than heretofore of primary sulphides in the limestones below the Carboniferous, even in the Cambrian. They do not constitute large bodies, and have been up to the present accidentally encountered. When their mode of occurrence is better understood they may constitute an important source of supply. A more noteworthy development was made in the exploration of the feldspathic rocks, especially in the prominent mass which composes Sacramento Mountain. These rocks promise to add notably to the life of the district. In the Clifton region a somewhat analogous occurrence took place in the discovery of copper along the line of certain faults to a depth considerably below the zone of secondary enrichment which was assumed to limit the occurrence of profitable ore. In the Globe district good ore was found to extend in depth below the limits at first assigned to it in the Miami, and the development of rich secondary ores down even to the 1600-ft. level of the Old Dominion added to the reserves on that large and persistent vein. The same persistence of ore in depth was realized on the United Verde, so that none of the old standard mines has yet shown the slightest symptoms of decline. On the other hand, no important new mines were opened.

Metallurgical activity was in the direction of replacing cupola by reverberatory smelting, owing to the increased quantity of concentrates supplied to the large smelting works. The Miami concentrates, shipped to the Greene-Cananea Company's works at Cananea, increased the output of the Cananea smeltery by from 3,000,000 to 3,500,000 lb. of copper per month, bringing the year's output of that establishment up to 75,000,000 lb.

The Copper Queen put two reverberatories and three roasting furnaces into service for handling the Nacozari concentrates. The Calumet & Arizona Company is almost replacing its old works by new construction, largely along reverberatory lines, and the Arizona Copper Co. expects before the close of the year to start its reconstructed works, consisting exclusively of reverberatories. The supply of ore likewise so exceeded the smelting capacity at the United Verde that Mr. Clark

is building new works in a more convenient situation. At Globe the Old Dominion concentrator was found too small, and so defective in construction that it is being enlarged under a better design. The output of the district within a limited number of months will be largely increased by the product of the Inspiration mill, whose concentrates it is currently supposed may be smelted on the spot by the Inspiration Company. But this large item of increase will not seriously add to the Arizona product in 1913, though the completion of the Ray mill, and increased activity by the Calumet & Arizona will probably run Arizona's output up to a somewhat higher figure than it has yet reached.

Arizona Copper Co.—This company has been an important producer for 30 years and has been producing from low-grade "porphyries" for that time. Leaching oxidized ores has been profitable for 25 years at this property. It is confidently expected with the able management that the many difficulties will be reduced. Improvements involving $3,000,000 in new construction are under way and costs will be lowered and reserves of lower grade made available. A new tunnel cutting the Coronado vein, 400 ft. below the present shaft bottom, is being vigorously driven. A record of 799 ft. of driving this 6 by 8 tunnel was made in 1 month.

During 1912, fiscal year ending Sept. 30, the production was 19,066 tons (2000 lb.) of bessemer copper, as compared with 17,284 tons in 1911. The ore mined, 70 per cent. of which came from the Longfellow group, amounted to 927,116 tons averaging 41.15 lb. About 96 per cent. of the ore was for concentrating, and 84 1/2 per cent. were classed as sulphide ores. 547,565 tons of ore were treated at No. 6 concentrator and 234,535 tons at the Clifton. The average ratio of concentration was 6.74 to 1. The capacity of No. 6 per day is now increased to 1573 tons; similarly the Clifton concentrator is improved. During the year 158,529 tons of ore and concentrate were smelted; the average yield was 12.03 per cent. copper.

The Shannon Copper Co. reports, for the year ended Aug. 31, 1912, a production of 16,406,336 lb. of copper, 170,691 oz. of silver, and 2615 oz. of gold, from which the returns were $2,594,867. The extraction was 285,210 tons, of which 42,125 tons came from open cut work. Experiments in leaching the semioxidized ores are still being carried in, but without commercial result so far.

The geology of the Turquoise mining district near Gleeson, Ariz., described by F. L. Ransome.[1] The district lies 14 miles due east of abstone and 18 miles northeast of Bisbee. Oxidized ore obtained a Carboniferous limestone east of Gleeson, and containing gold, silver,

ll. 530, *U. S. Geol. Surv.* The Turquoise Copper Mining district, Arizona.

lead and copper, ceased to be produced in 1902. Lower grade pyritic ores are now utilized from the Copper Belle Mine, under lease to the Shannon Copper Co., the extension of the railroads making this ore accessible.

The Humbot claim near Courtland is reported to have produced oxidized ores valued at $100,000 by the year 1901. Later, in the course of exploration in 1907, the Calumet & Arizona Co. shipped 15,000 to 20,000 tons of 7 per cent. ore from the Germania. Toward the end of 1911 the Great Western Copper Co. had produced 30,000 tons of ore from the Mary mine, on the same ore-body. The only other producing mine, the Marne, belongs to the same company. The Mary was shipping 450 tons per week in 1911. The types of deposit are oxidized blanket deposit connected with thrust faulting (Germania and Mary); pyritic with some oxidized ore in Cambrian dolomite and shale (Marne and Leadville mines); pyritic with enriched ore in carboniferous limestone (Copper Belle).

The Shattuck-Arizona Copper Co. for the year ended July 31, 1912, reports the following: Wet tons of ore all from development work only, 3094; equivalent dry tons, 2802; copper recovered, 1,253,305 lb.; silver recovered, 21,008 oz.; gold recovered, 13 oz. To date there have been 40,378 ft. of development work done, of which 4942 were done in the year under review. On the 400-ft. level an important find of carbonate ores in limestone has been made (35 per cent. CaO), while ferruginous ores have been found on the 600 level. A smeltery has been planned to be erected at Douglas, and will have a capacity of 400 tons per day, the estimated cost is $400,000, which is equivalent to about $2.77 per ton of annual capacity.

The ore is now shipped to the C. & A. The Shattuck mine was reopened in Oct., 1912. The management estimated 22,000,000 lb. production for 1913.

Miami (By J. Parke Channing).—In 1912 the development of the Miami ore-body for mining was extensively carried forward by extending the extraction drifts on the 420-ft. level so as to undercut the main ore-body on that level, and also to get underneath the Captain ore-body and to connect with the Captain shaft. The development of the 570-ft. level was extensive so as to prepare this level for an extraction level. It is being cut up in the same rectangular-gridiron fashion as the 420-ft. level, and is so arranged that when the final method of mining is determined upon, it will be available for any method selected. The third extraction level was arranged for in the main shaft at a depth of 720 ft., but nothing has been done at this point as it may be advantageous

to put this level to a still greater depth, depending upon the ore development.

Of the ore mined in 1912 a large proportion came from development work and from the square sets and slicing. The shrinkage stopes which have been tried out on the 420-ft. level are nearly all in shape, but the work of cutting out with square sets above them and the intervening pillars was not completed. The indications, so far, are that a method of combined shrinkage stopes and pillar caving will prove to be economical both as regards percentage of extraction and cost.

The early estimates of ore reserves assumed the ore to extend to a depth of only 50 ft. below the 570-ft. level. During the latter part of 1912, eight diamond-drill holes were put down from the 570-ft. level showing that the ore extends in places from 100 to 200 ft. below that level, and in some places the bottom was not reached. The indications are that the ore will go to a much greater depth than was expected, following along the line of the Gila conglomerate fault. The results of 1912 show a material increase in the ore in sight, it now being 20,800,000 of an average grade of 2.48 per cent. copper, together with excellent prospects for continuation in depth. Churndrill work has developed 17,000,000 of ore of a grade of 1.21 per cent. copper not yet classed as merchantable.

In January, 1912, the mill was treating at the rate of 2200 tons per day, and since June 1 at the rate of nearly 3000 tons per day. The production for the year was 32,832,609 lb. of refined copper. The year's work in the mill demonstrated the increased efficiency of the Hardinge pebble mills over the Chile mills, and orders have been placed for Hardinge pebble mills to replace the Chile mills as they are worn out. An extremely heavy type of intermediate 42 by 16-in. roll developed by the Traylor Engineering & Manufacturing Co., is being introduced, one at a time, in each section of the mill. In addition to this, experiments indicated the desirability of finer crushing of the ore to liberate a certain amount of the mineral which is at present lost in the sand tailing, and these improvements will gradually be installed during 1913. The indications are that with these betterments the capacity of the present mill can be materially increased over its present limit of 3000 tons per day.

In the power house the spaces left for new machinery were filled by the installation of a 600-h p. boiler, a 4000-cu. ft. air compressor, a 1250-kw. generating set, and a second condenser. A second 400-h.p. synchronous motor was installed at the Burch pump station, thus giving the pumping plant with its two pumps a capacity of 2400 gal. of water per. minute. A tailing elevator was installed below the mill, raising the tailing to a height of 75 ft. and permitting of its discharge in the second

gulch beyond the mill. On the surface, a number of houses were built, and a hospital, jointly owned by the Miami and the Inspiration, is now being erected.

The report of the Miami Copper Co. for the year ended Dec. 31, 1912, shows that a profit of $2,094,805 was made, out of which three dividends, aggregating $1,110,112, were paid.

Tons ore treated—1911, 445,036 of 2.48 per cent. Cu; 1912, 1,040,744 of 2.39 per cent.

Concentrator production—1911, 16,195,561 lb.; 1912, 34,560,665.

Net smelter production—1911, 15,385,783 lb.; 1912, 32,832,609.

Extraction (net)—1911, 34.57 lb. per ton; 1912, 31.55.

SUMMARY OF COSTS

| | 1911. | | 1912 | |
|---|---|---|---|---|
| | Per ton | Per lb. | Per ton | Per lb. |
| Mining | $1.2134 | $0.03500 | $1.2032 | $0.03813 |
| Milling | 0.6274 | 0.01810 | 0.6586 | 0.02087 |
| General expense | 0.2514 | 0.00714 | 0.1802 | 0.00577 |
| Freight on concentrate | 0.2174 | 0.00629 | 0.2173 | 0.00689 |
| Smelting, refining, etc. | 0.8041 | 0.02326 | 0.7323 | 0.02321 |
| Selling | 0.0591 | 0.00171 | 0.0405 | 0.00128 |
| New York office | 0.0605 | 0.00175 | 0.0386 | 0.00122 |
| Total | $3.2333 | $0.09325 | $3.0707 | $0.09739 |
| Ag, Au, etc. | 0.0767 | 0.00222 | 0.0477 | 0.00151 |
| Net cost | $3.1566 | $0.09103 | $3.0230 | $0.09588 |

Inspiration.—During 1912, 32,833 ft. of underground work were done on the Inspiration and Live Oak divisions of the mine. The average thickness of ore as shown by churn drills, 229 holes of 124,886 ft. total, was 142 ft. and 114 ft., respectively, for the two divisions. No additions to ore reserves were made by the underground work as this was only for extraction. At the time of consolidation, the reserves were 45,000,000 tons of 2 per cent. ore.

The comparative figures of an ore block (600 ft. of the Joe Bush claim) are as follows: Original estimate by Henry Krumb, based on five churn-drill holes and 4325 ft. of underground work; tons of ore, 2,475,000; per cent. copper, 1.95. Recent estimate by V. A. Hart, based on sampling of 15,165 ft. of underground work in same block; tons of ore, 2,525,000; per cent. copper, 1.93. Estimate made by substituting regular mine samples for Mr. Hart's samples of same underground working; tons of ore, 2,525,000; per cent. copper, 2.

This estimate very properly covered sulphide ores only. The drill-holes, however, show in addition, above the total area of sulphides, approximately 8,000,000 tons of oxidized and semi-oxidized ore averaging 1.4 per cent. copper, and there is unquestionably more in other adjacent areas. This semi-oxidized material has been classified, through conserva-

tism, with the barren capping. It immediately overlies the ore. In any caving system of mining it will replace in part the otherwise barren capping that unavoidably in some degree will be mixed with the ore. In grinding this material the oxide copper is largely concentrated in the slime. If this oxide copper were treated by leaching as auxiliary to the regular sulphide concentration, it is probable that such of this semi-oxidized ore as is unavoidably drawn with the sulphide ore in caving might be made to yield net returns above the reduction costs.

The ore from the mine will be hoisted through two main shafts, 104 ft. apart, on the Gift claim in Webster gulch, and outside the known ore-body. These two shafts have each been sunk to a depth of 585 ft., such being a suitable distance below the second and lowest level of the Inspiration mine.

The contract for steel construction of the head frames, crushing plant, bins and concentrator building were let in November, 1912. Experiments with a 50-ton plant of the Minerals Separation, Ltd., may lead to modification of the original concentrator as planned in accordance with water concentration tests by Mr. J. M. Calloro, which promised good results. The flotation process above is said to save 93 per cent. of the copper, with a 40 per cent. concentrate. The combination process is expected to yield an extraction of 88 per cent. with 35 per cent. concentrate from the schist ore. Railroad connections will be completed early in 1912.

The report of Phelps, Dodge & Co. for the year ended Dec. 31, 1912, shows copper deliveries of 192,297,374 lb., an increase of 11,995,409 lb. over 1911, of which 139,759,515 lb. was its own product. The production was 148,678,889 lb. of copper, of which 140,628,798 lb. was from company ore; 1,689,152 oz. of silver, of which 1,104,510 was from company ore; and 27,687 oz. of gold, of which 16,002 was from company ore. The copper ore extracted from the mines was 1,893,244 tons, of which 1,098,528 tons were concentrated, and 794,716 tons smelted. Including ore, concentrates, slag, and cement copper the total smelted was equivalent to 1,051,315 tons, of which 97,574 tons of ore and concentrates were purchased.

In addition 11,626 tons of lead ore were produced at Bisbee and sold, yielding 30,434 lb. of copper, 2,953,685 lb. of lead, 326,962 oz. silver, and 3889 oz. of gold. The mines at Bisbee (Copper Queen Company) produced 786,368 dry tons of ore, including the lead ore listed above, which was shipped to El Paso, while 30,164 tons of sulphide ore were sent to Globe. The Copper Queen reduction works treated 672,380 tons of Copper Queen ores and precipitates, 59,850 tons of Copper Queen dump slag and cleanings, 9027 tons of lease ores, 124,083 tons of

Moctezuma concentrates, and 97.574 tons of custom ore, a total of 962,914 tons, from which 123,876,100 lb. of copper; 1,689,152 oz. of silver; and 27,687 oz. of gold were recovered, contained in 124,915,708 lb. of bullion.

The production in 1911 was 111,445,229 lb. copper, 1,794,895 oz. silver and 27,154 oz. gold. An interesting and authoritative history of the Copper Queen mines was given by Dr. Douglas before the Institution of Mining and Metallurgy.[1]

In the Bisbee mines development work amounted to 78,135 ft. during the year. Ore reserves were increased materially, and the exploratory work throws considerable light on the subject of primary ores. Only 14.9 bd.-ft. of lumber were used per ton in stoping, against 16.6 ft. in 1911, through mining by cutting and filling without systematic timbering.

In the smelting department 1,095,861 tons of charge were treated, with 12.78 per cent. of coke. The ash in the coke accounted for 45,765 tons of slag, or 6.7 per cent. of all the slag made. Flue dust recovered amounted to 64,662 tons, or 5.9 per cent. of the charge, but the amount dropped from 8.87 per cent. in June to 2.72 per cent. in December, due to deflecting the converter fume from the blast-furnace dust chambers, and to treating fine in a reverberatory plant which began operating on June 16. Basic converting completely displaced acid, and now the change is being made to the Great Falls type of shell.

The Detroit Copper Mining Co., at Morenci, mined 501,541 tons of concentrating ore; 6191 tons of smelting; and 11,990 tons of siliceous ore, and treated 520,272 tons of ore, producing 24,802,789 lb. of bullion. From 501,928 tons of 3.08 per cent. concentrating ore, there were 70,438 tons of 16.69 per cent. concentrate produced. The blast-furnace smelted 160,649 tons of charge, of which 75,784 tons were ore and concentrate, and 18,451 tons, coke. The recovery is placed at 93.86 per cent.

COPPER QUEEN MINES PRODUCTION.

| | Tons. | Copper lb. | Silver oz. | Gold oz. |
|---|---|---|---|---|
| Ore mined and shipped to Douglas | 669,399 | 81,422,404 | 656,838 | 13,520 |
| Precipitates shipped to Douglas | 998 | 1,036,735 | 285 | ..... |
| Slags, etc., to Douglas | 64,770 | 2,997,226 | 5,885 | 2 |
| Lessor's ore shipped to Douglas | 9,411 | 2,074,825 | 36,535 | 612 |
| Sulphide ore shipped to El Paso | 11,626 | 6,188 | 18,140 | 3,889 |
| to Globe | 30,164 | 719,194 | 625 | ..... |
| Total, 1912 | 786,368 | 88,280,908 | 1,027,130 | 18,023 |
| Total, 1911 | 619,132 | 74,489,728 | 1,227,453 | 16,895 |

[1] *Eng. and Min. Journ.*, March 8, 1913.

CONCENTRATOR STATISTICS, DETROIT COPPER COMPANY, 1912.

| | Tons. | Per Cent. Copper. |
|---|---|---|
| D. C. Co., ore concentrated .... .... | 501,928 | 3.08 |
| Concentrates produced..... | 70,438 | 16.69 |
| Saving, percentage..... | ..... | 76.41 |
| Tailings assay..... | ..... | 0.821 |
| Tons milled per ton of concentrate.. | 6.78 | ..... |
| Water used per ton of concentrate.. | 554.4 gal. | ..... |
| Actual running time for year..... | 95.36% | ..... |
| Ore milled per 24 hours..... | 1,362.2 | ..... |

MOCTEZUMA COPPER COMPANY.

| Year. | Pounds Copper. | Net Earnings. |
|---|---|---|
| 1905..... | 10,160,016 | $533,117.66 |
| 1906..... | 12,714,726 | 1,195,424.18 |
| 1907..... | 9,640,390 | 833,236.25 |
| 1908..... | 15,522,580 | 524,902.00 |
| 1909..... | 26,487,776 | 1,104,454.00 |
| 1910..... | 22,632,180 | 480,690.55 |
| 1911..... | ..... | 1,206,183.00 |
| 1912..... ..... | 31,739,748 | 2,735,060.98 |

COPPER QUEEN STATISTICS. (a)

| Year. | Production, Pounds. | Net Earnings. | Dividends. |
|---|---|---|---|
| 1905..... | 64,625,955 | $5,609,486.30 | $2,300,000 |
| 1906..... | 79,219,655 | 7,625,854.76 | 6,500,000 |
| 1907..... | 63,341,055 | 4,471,137.08 | 3,800,000 |
| 1908..... | 76,125,162 | ..... | 3,000,000 |
| 1909..... | 84,429,791 | 5,271,278.20 | 4,025,000 |
| 1910..... | 76,428,908 | 4,623,856.12 | 6,300,000 |
| 1911..... | 111,445,229 | 4,155,011.00 | 5,200,000 |
| 1912..... | 123,876,100 | 6,977,378.14 | 5,707,351 |

(a) The difference between earnings and dividends is represented by expenditure on increased plant facilities, and undistributed. Since 1887 the company has paid a total of $51,292,351 in dividends.

DETROIT COPPER MINING COMPANY.

| Year. | Production, lb. | Net Earnings. | Dividends. (a) |
|---|---|---|---|
| 1905..... | 14,632,117 | $532,684.28 | ..... |
| 1906..... | 20,347,497 | 973,456.42 | ..... |
| 1907..... | 17,974,581 | 814,874.11 | $80,000 |
| 1908..... | 24,223,172 | 1,072,016.00 | 480,000 |
| 1909..... | 24,591,021 | 1,153,269.66 | 760,000 |
| 1910..... | 23,056,292 | 1,079,546.90 | 1,840,000 |
| 1911..... | 22,704,398 | 930,496.00 | 800,000 |
| 1912..... | 24,802,789 | 1,406,170.56 | 1,464,610 |

(a) The company had paid a total of $9,822,200 in dividends up to the end of 1910.

At the Moctezuma plant, Nacozari, Mexico, the development work below Porvenir tunnel bears on the evidence of ore in depth. 16,206 ft. of this work was done. 596,600 tons of 3.494 per cent. Cu ore was milled, yielding 131,062 tons of 13.373 per cent. Cu concentrates.

The annual reports of the Old Dominion Copper Mining & Smelting Co. and the United Globe Mines, of Globe, Ariz., are published with the report of the holding corporation, the Old Dominion Co. The Old Dominion Copper Mining & Smelting Co. extracted during the year 93,592 tons of 6.43 per cent. smelting ore, 106,232 tons of 3.15 per cent. concentrating ore and 1357 tons of silica lining carrying 2.7 per cent. copper. The average grade was 4.67 per cent. as against 5.84 per cent. for the previous year. The mining cost was $4.55 per ton as against $4.18 for 1911.

Development consisted of 10,964 ft. of drifting, 4092 ft. of raising, and 203 ft. of sinking. The amount of water pumped increased about 13 per cent., the average daily flow being a little short of 4,000,000 gal. Of the total flow for the year, 732,000,000 gal. were sold to the Miami Copper Co. Power costs in 1912 were $64.04 per horse-power year, a reduction of about 24 per cent. from 1911, due largely to a new contract for fuel oil.

The concentrator, in addition to the mine ore, handled 60,638 tons of custom ore. The average copper content of both classes was 3.37 per cent. The concentrating cost for the year was $0.753 per ton, a decrease of about 25 per cent. from the previous year. The smeltery handled 306,086 tons of ore at a cost of $2.304 per ton and produced 27,353,243 lb. of copper, 143,011 oz. of silver and 3202 oz. of gold. Of the smeltery production 16,534,000 lb. of fine copper, 42,751 oz. of silver and 583 oz. of gold were from Old Dominion ore, the balance was from custom ores. There was realized on the Old Dominion ore, $2,751,899, increased by profits on custom ores and by miscellaneous earnings to $2,888,204. After deducting expenses the net earnings were $1,004,186. Dividends of $729,000 were paid.

The United Globe Mines during 1912 extracted and shipped 188,254 tons of oxide and sulphide ores, concentrating ores, converter lining, silica and slag, of which the average tenor of copper was 3.25 per cent. The amount of metal obtained from the total shipments was 12,252,073 lb. of copper, 124,362 oz. of silver and 789 oz. of gold. Development work included 3226 ft. of raising, 11,393 ft. of drifting and 321 ft. of sinking, in addition to which the Kingdom shaft was concreted, the Grey shaft retimbered, and about 720 ft. of repair work done on the third and seventh levels of the Grey shaft and the lower tunnel of the Buffalo mines. The amount received from ore sales was $1,309,214, increased by sales

of lime rock and by interest received to $1,319,451. After deducting expenses the net earnings for the year were $619,476. Dividends of $460,000 were paid during the year.

The Old Dominion Co. (holding corporation) reports dividends on stock owned of $1,159,244, interest receipts of $28,103 and a net income of $1,180,235.

STATISTICS UNITED VERDE.

| | 1907. | 1908. | 1909. | 1910. | 1911. |
|---|---|---|---|---|---|
| Copper production, lb | 33,012,339 | 36,183,089 | 36,694,063 | 38,663,800 | 33,167,987 |
| Silver production, oz | ..... | 494,574 | 495,480 | 563,133 | 461,145 |
| Gold production, oz | 11,730 | 20,334 | 17,022 | 19,267 | 15,239 |
| Cost of mining | $1,068,293 | $796,529 | ..... | ..... | ..... |
| Cost of smelting | 1,281,674 | 1,215,993 | ..... | ..... | ..... |
| Charged to depreciation | 298,243 | 320,407 | ..... | ..... | ..... |
| Price received for copper, per lb | 18.167c. | 13.343c. | 12.97c. | 12.69c. | 12.59c. |
| Price received for silver, per oz | 64.158c. | 52.453c. | ..... | ..... | 52.4 c. |
| Price received for gold, per oz | $20.50 | $20.50 | ..... | ..... | 20.72c |
| Cost of copper, per lb (a) | 10.54c. | 9.046c. | ..... | ..... | ..... |

(a) Value of the precious metals is not credited against cost of producing the copper.

CALUMET & ARIZONA MINING COMPANY.

| Year. | Net Earnings. | Copper Produced, lb. | Price Received. | Gold and Silver Value. | Gross Product. | Cost Per lb. |
|---|---|---|---|---|---|---|
| 1905 | $2,314,268 | 31,772,896 | 14.932c. | $178,843 | $4,923,172 | 8.21c. |
| 1906 | 4,827,872 | 37,470,284 | 17.96c. | 238,464 | 6,968,127 | 5.71c. |
| 1907 | 2,114,047 | 30,689,448 | 18.102c. | 210,846 | 5,765,636 | 11.22c. |
| 1908 | 857,700 | 28,048,329 | 12.948c. | 234,358 | 3,859,854 | 11.00c. |
| 1909 | 1214,495 | 27,630,050 | 13.531c. | 211,760 | 3,950,311 | 10.38c. |
| 1910 | 1,119,848 | 28,029,506 | 12.9316c. | 265,364 | 3,889,927 | 9.72c. |
| 1911 | 893,639 | 21,476,739 | 12.4922c. | 301,369 | 2,983,665 | 8.33c. |
| 1912 | 2,932,718 | 16,490,229 | 15.6 | 323,252 | 2,897,024 | 8.56 |

The consolidated statement of the Calumet & Arizona Mining Co. and the Superior & Pittsburgh Copper Co. for the year ended Dec. 31, 1912, shows total earnings on copper, silver and gold of $9,083,988, which is increased by interest and miscellaneous earnings to $9,131,968; operating expenses deducted from this sum left a total of $4,540,883. There were produced during the year 53,108,628 lb. of refined copper, together with 594,319 oz. of silver and 22,881 oz. of gold. The value of the precious metal per ton of refined copper was $30.86 and the net cost of refined copper after deducting the value of the precious metals was 7.02 cents per lb. During the year the Calumet & Arizona Company paid dividends amounting to $2,452,781 and the Superior & Pittsburgh Company paid $1,919,733, but of the income of the Calumet & Arizona $1,785,454 were dividends received, of which all or most was paid by the Superior & Pittsburgh.

The Calumet & Arizona Company reports an extension of the time for final payment on the New Cornelia Copper Co. property at Ajo, Ariz.,

until Oct. 1, 1913, when $800,000 will be required. A favorable option has been taken on the Daggs-Newman group of claims near Superior, Ariz., which allows two years' development work without payment. Acquisition of the American-Saginaw holdings in the Bisbee district is recommended. During the year the Calumet & Arizona did over 25,000 ft. of drifting and raising and the Superior & Pittsburgh did about 29,500 ft. of sinking, drifting and raising. The Cortland mines of the Calumet & Arizona were re-opened during the summer and shipments at the rate of 600 tons per week were continued from July 25 on. A total of 785 ft. of development was also done there. The Calumet & Arizona shipped 176,049 dry tons of ore to the smeltery, in which the average percentage of copper was 5.077. The Superior & Pittsburgh shipped 288,845 dry tons to the smeltery with an average copper content of 6.361 per cent. In August the Superior & Pittsburgh purchased the Wedge and Last Chance claims in the Bisbee district.

The smeltery at Douglas is now handling 250 tons per day from the Shattuck-Arizona Copper Co., which will be increased to 500 tons when the new plant is completed. Work on the new plant is progressing satisfactorily and it is hoped that it will be in operation by Aug. 1, 1913, the time originally set.

The report of the Ray Consolidated Copper Co. for December 31, 1912, states that no drilling or development work of any character was done during the year. The total tonnage mined from the beginning of operations up to the end of 1912 was 2,247,395 tons averaging 1.72 per cent. copper; the total known tonnage remaining in the developed area is 80,656,973 tons averaging 2.2 per cent. copper. The total area developed and included in price calculations is 205.2 acres.

The original property of the company was opened up for underground mining in two vertical shafts, situated nearly a mile apart. After the acquisition of the Ray Central property a third shaft was sunk, but no tonnage was produced through it during the year. The total amount of underground development for the year amounted to 133,345 ft., bringing the total since the beginning up to 292,243 ft.

The tonnage of ore mined from development was 29.3 per cent. of the total; that from active stopes 44.7 per cent., and from reserve 26 per cent. It is expected that the percentage of tonage obtained from reserve will increase rapidly, and consequently mining cost will decrease accordingly. The ideal or most economical state will not be reached until 50 to 75 per cent. of the ore, depending on the varying local conditions, is derived from such reserve sources.

The total direct cost of mining for the year, including crushing of the ore through an inch-mesh screen and delivery of it on board cars,

together with a proper apportionment of all general and fixed charges, was 77.55 cents per ton.

The mining costs for the last quarter of the year on the same basis were 71.5 cents per ton. The costs stated here do not, however, include the regular charge of 12 1/2 cents per ton against operation for the retirement of mine-development suspense account.

During the year the installation of a new compressor at the No. 1 plant was completed. This machine, having a capacity of 5000 cu. ft. of free air per minute, has been in successful operation for several months. A duplicate set of crushers and rolls was being installed at the No. 2 shaft with the intention of using it as a protection against delays in case of accident or necessity of repairs.

The Hayden mill consists of eight independent sections, each having a rated capacity of 1000 tons per day. At the end of the year seven sections were complete, six of them in continuous operation and the seventh running intermittently as required.

The total ore treated during the year was 1,565,875 tons as compared to 681,519 tons for the nine months of the year 1911 during which the mill was running. The average tonnage per day for the year was 4278. The average copper content of the ore treated was 1.677 per cent., and the average recovery for the year based upon the total copper contained in concentrate produced was 68.2783 per cent. corresponding to a recovery of 22.9 lb. of copper per ton of ore. The cost of milling was 46.878 cents per ton as compared with 58.45 cents for the previous year. The total production during the year of copper contained in 18.94 per cent. copper concentrate was 35,851,496 lb. The average cost per pound of copper produced, based on the net copper returns from concentrate after smelting and refining deductions were made and after applying the dividends from the Ray & Gila Valley R. R., but not other miscellaneous earnings, was 9.828 cents. The average total cost for the year for mining and milling exclusive of transportation charges on ore, but including for the second, third and fourth quarters of the year a charge of 12 1/2 cents per ton of ore treated for extinguishment of mine development cost, was $1.345 per ton.

The Hayden plant, Gila County, Arizona, started by the Ray Consolidated Copper Company, but completed as a customs plant by the A. S. & R. Co., is probably the most important plant completed during 1912.

*California.*—The decrease in copper in 1912, and incidentally the silver production, was due to the continued suspension of the Balaklala and also to the experimenting at the Campo Seco smeltery. At the latter the thiogen process is being tried. The farmers in the copper-mining

regions continued their war on the smelteries, and were also particularly active against the Selby plant.

The re-opening of old mines in Calaveras County, such as the Ingomar, at Campo Seco, and the Calaveras copper mine, at Copperopolis allowed some development work to be accomplished. At the last-named mine, auto trucks were installed for hauling ore to the railroad; some high-grade copper ore was shipped.

In Shasta County, the Mammoth copper mine and smeltery operated throughout 1912; development was advanced and new ore-bodies encountered.

It is reported that the Calaveras Copper Co. will blow in its Copperopolis smelter. After the Mammoth Company, this is the largest producer of copper in California. The plant has a capacity of about 2,000,000 lb. per month. Some shipments of ore made early in 1913 to the Kennett smelter averaged 12 to 15 per cent. copper.

The Mountain Copper Company is reported as contemplating experiments at Keswick with the object of smelting without discharging noxious fumes.

*Colorado* (By G. E. Collins).—There was no marked change in the copper output of the state. Copper is in the main a by-product from gold and silver ores, although in a few cases an exceedingly important one. The output being scattered and comparatively small, the ore must necessarily be sold to lead smelteries under rather disadvantageous conditions. The only producing properties which can be properly classed as copper mines are in the San Juan district, notably the Indiana, and the Congress at Red Mountain; for the treatment of these ores the pyritic smelting works at Ouray is being remodeled and placed in operation.

*Idaho* (By Robert N. Bell[1]).—The Snowstorm mine, near Mullan, in Shoshone County, made an output of 74,000 tons of ore. The bulk of it was shipped crude to different copper smelters of the West, by whom it is used as converter lining because of its high silica contents. It carries an average of 3 per cent. copper and 5 oz. of silver, in the form of carbonate disseminated through quartzite. The lower levels of this mine produce finely disseminated chalcopyrite and chalcocite ore. The old leaching plant of this company was transformed into a concentrator, which is now treating 125 tons per day and making a 60 per cent. saving, the concentrate running about 25 per cent. copper and 27 oz. silver per ton.

A new development was made late in 1912 at the National mine, 1 1/2 miles west of the Snowstorm, in the same series of quartz beds and fractures, that promise to prove of the utmost importance to this locality.

[1] State mine inspector, Boise, Idaho.

The discovery was made at a depth of 1700 ft. through a cross-cut 4380 ft. long; it presents a body of disseminated copper-sulphide ore, identical in appearance and value with some of the best sulphide stopes of the Snowstorm mine, that is now proven to be over 60 ft. thick in two cross-cuts 100 ft. apart and considerable further lineal extent is indicated.

The White Knob mine, at Mackay, in Custer County, owned by the Empire Copper Co., enjoyed a prosperous year. During the greater part of 1912 this property shipped 2500 tons per month of crude ore, which averaged 6 per cent. copper and $3.20 gold and silver per ton. Owing to the ore being oxidized, and the fluxing value of its gangue, it is sent to the Salt Lake Valley smelters. Most of this ore was produced by small leasing operations, scattered over the extensive area of this company.

*Michigan* (By Carl L. C. Fichtel[1]).—The year 1912 was a prosperous one for the Lake Superior district. The price of copper during the greater portion of the year was such that the producing mines were operated at a substantial profit, resulting in an increase of dividends and affording an opportunity for some mines to acquire a surplus.

Wages on all classes of labor were increased throughout the district about May 1, 1912, but a scarcity of trammers during the summer months materially handicapped some of the smaller outlying properties in increasing production. One-man drilling machines were adopted at several properties and are gradually supplanting the two-man machines. Considerable attention was given to scientific engineering and greater efficiency was obtained in the various branches of mining. "Dollar rock" was obtained at the South Kearsarge branch of the Osceola Consolidated. Tube mills for regrinding the tailings were introduced in some of the mills and others made preparations for their adoption. A working man's compensation and employer's liability law went into effect and was universally adopted by the mines. The Sturgeon River Land & Improvement Co. was incorporated and will construct a hydro-electric plant to supply the mines of the district with cheap power.

The Keweenaw Copper Co. acquired about 6000 acres of land on the trend of the Ashbed lode and made an exchange on a stock basis with the Phoenix and Washington companies which will give the combined company a stretch of about 13 1/2 miles on the Ashbed formation. Toward the end of 1912 two drilling outfits were put in commission. A small force of men was employed at the Cliff property and openings were extended on the Kearsarge lode. At the Ojibway, development work was carried on in both shafts. The formation is bunchy and of an unsettled nature. A large stockpile has been accumulated. The five producing Mohawk shafts maintained about normal production, and the rock

[1] Electrical department, Calumet & Hecla Mining Co., Calumet, Mich.

taken from the openings of the No. 6 shaft was also sent to the mill. Permanent equipment for No. 3 and 4 shafts of the Ahmeek will be ready to go into commission early in 1913. The property maintained its record of low costs and high-grade rock. It is planned to enlarge the stamp mill to meet the increase in production from shafts Nos. 3 and 4. The new steel rock house and enlarged equipment at No. 2 Allouez shaft which went into commission during the summer resulted in increased production. At the stamp mill, owned jointly by this and the Centennial company, two heads were altered.

At the Wolverine mine a slight decrease in the copper content of the rock was experienced for a couple of months, but the company rounded out the year with the mineral yield up to normal.

DIVIDENDS PAID BY MICHIGAN MINES.

| Mine. | 1910. | 1911. | 1912. | Mine. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|
| Calumet & Hecla | $2,400,000 | $2,400,000 | 4,200,000 | Quincy ... | $550,000 | $440,000 | $550,000 |
| Copper Range Con. | 1,357,104 | 1,357,104 | 2,100,000 | Tamarack. | ..... | ..... | ..... |
| Mohawk..... | 200,000 | 175,000 | 350,000 | Wolverine | 600,000 | 540,000 | 550,000 |
| Osceola..... | 769,200 | 673,050 | 1,153,800 | Totals.... | $5,647,836 | $6,231,840 | $9,069,259 |

COPPER PRODUCTION IN MICHIGAN.
(Pounds of fine copper.)

| Mines. | 1904. | 1905. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|---|---|
| Adventure.. | 1,380,480 | 1,606,208 | 1,552,628 | 1,244,872 | 90,870 | *Nil* | *Nil* | *Nil* | 8,727,312 |
| Ahmeek..... | 350,000 | 1,552,957 | 3,077,507 | 5,527,672 | 6,280,241 | 9,198,110 | 11,844,954 | 15,196,127 | 16,455,769 |
| Allouez..... | ..... | 1,167,957 | 3,486,900 | 2,934,116 | 3,047,051 | 4,031,532 | 4,655,702 | 4,780,494 | 5,525,455 |
| Atlantic..... | 5,321,859 | 4,049,731 | 1,439,082 | *Nil* | *Nil* | 43,483 | 19,018 | *Nil* | *Nil* |
| Baltic..... | 12,177,729 | 14,384,684 | 14,397,557 | 16,704,868 | 17,724,854 | 17,817,836 | 17,549,762 | 15,370,449 | 13,373,961 |
| Cal. & Hecla. | 80,341,019 | 83,812,370 | 94,529,821 | 88,055,723 | 81,660,723 | 74,593,553 | 72,672,469 | 72,861,925 | 67,856,429 |
| Centennial... | 641,294 | 1,446,584 | 2,253,015 | 2,373,572 | 2,196,377 | 2,583,793 | 1,572,566 | 1,493,834 | 1,742,338 |
| Champion... | 12,212,954 | 15,707,427 | 16,954,986 | 16,489,436 | 17,786,763 | 18,005,071 | 19,224,124 | 15,639,426 | 17,225,508 |
| Franklin .... | 4,771,050 | 4,206,085 | 4,571,570 | 4,401,248 | 3,703,421 | 1,615,556 | 966,353 | 820,203 | 1,710,651 |
| Isle Royale.. | 2,442,905 | 2,973,761 | 2,937,098 | 2,667,608 | 3,011,664 | 5,719,056 | 7,567,399 | 7,490,120 | 8,186,957 |
| Mass..... | 2,182,931 | 2,007,950 | 2,106,739 | 2,078,677 | 1,766,930 | 1,723,436 | 1,321,885 | 1,326,898 | 2,045,006 |
| Michigan.... | 2,746,127 | 2,891,796 | 2,875,341 | 2,665,404 | 3,000,206 | 1,979,305 | 36,682 | 327,773 | 300,000 |
| Mohawk..... | 8,149,515 | 9,387,614 | 9,352,252 | 10,107,266 | 10,295,881 | 11,248,474 | 11,412,066 | 12,091,056 | 11,995,598 |
| Osceola..... | 20,472,439 | 18,938,965 | 18,588,451 | 14,134,753 | 21,250,794 | 25,296,657 | 19,346,566 | 18,388,193 | 18,413,387 |
| Phoenix..... | 1,162,201 | 273,219 | *Nil* | *Nil* | *Nil* | *Nil* | *Nil* | *Nil* | *Nil* |
| Quincy..... | 18,343,160 | 18,827,557 | 16,194,940 | 19,796,058 | 20,600,361 | 22,511,984 | 22,517,014 | 22,252,943 | 20,634,800 |
| Superior..... | ..... | ..... | ..... | ..... | 21,244 | 1,789,315 | 3,181,041 | 3,236,233 | 3,921,974 |
| Tamarack... | 14,961,885 | 15,824,008 | 9,832,644 | 11,078,604 | 12,806,127 | 13,533,207 | 11,063,606 | 7,494,077 | 7,908,746 |
| Trimountain | 10,211,230 | 10,476,462 | 9,507,933 | 8,190,711 | 6,034,908 | 5,282,404 | 5,694,868 | 6,120,417 | 6,980,713 |
| Winona..... | 646,025 | *Nil* | 278,182 | 1,285,863 | *Nil* | *Nil* | *Nil* | *Nil* | 2,307,237 |
| Wolverine... | 9,764,455 | 9,464,418 | 9,548,123 | 9,273,351 | 9,555,233 | 9,971,482 | 10,469,253 | 9,630,639 | 9,408,960 |
| Victoria..... | ..... | ..... | ..... | 1,207,237 | 1,290,040 | 1,164,564 | 1,164,564 | 1,303,331 | 1,224,911 |
| Others..... | 50,000 | ..... | ..... | 100,000 | ..... | 2,862,233 | 899,647 | 294,873 | |
| Totals .... | 208,392,485 | 218,999,753 | 224,071,103 | 220,317,041 | 222,123,688 | 230,971,051 | 223,179,539 | 216,119,011 | 225,945,712 |

The Mayflower Mining Co. secured some of the most remarkable drill cores ever taken from the district. The core from hole No. 22 carried copper for practically the entire distance between 1011 and 1133 ft.; 88 ft of this distance showed an average of 30.8 lb. per ton. The

formation is a comparatively soft amygdaloid. The cores taken from holes Nos. 15 and 17, the discovery holes, showed 26 and 32 lb. of copper per ton, respectively. A. L. Dickerman, of Boston, has been in charge of the exploratory work. The Old Colony Copper Co. succeeded in identifying this same formation on its lands.

The shaft on the St. Louis property of the Calumet & Hecla Co. was put down to a depth of about 500 ft. On the conglomerate lode, all the Calumet & Hecla shafts with the exception of No. 12, and most southernly, were operated throughout 1912. The five shafts on the Osceola amygdaloid lode contributed nearly 40 per cent. of the rock treated. No. 21 shaft on the Kearsarge lode revealed ground above the average richness for this formation. The company erected an addition to the electric power plant at Lake Linden and started the installation of a 7500-kw. low-pressure steam turbine to utilize the exhaust steam from the stamps. The building for the second regrinding mill was completed and the plant will go in commission in 1913. This mill will contain 64 Hardinge conical mills, together with tables, etc., which are being constructed at the company shops. At the smeltery the new furnace building was nearly completed and the foundations completed for a new electrolytic plant to be ready in 1913. This plant will be used instead of the company's Black Rock plant at Buffalo, N. Y., which will be closed.

The Tamarack Mining Co. did considerable stoping on the Osceola amygdaloid lode; the company showed a surplus for the year. Alterations were made at the stamp mill and a Hardinge conical mill was installed to make an experimental run on the tailing piles. The Osceola Consolidated Mining Co. resumed operations at Nos. 5 and 6 shafts of the main mine; at No. 1 shaft of the North Kearsarge branch a new steel rock house and enlarged hoisting equipment are in the course of erection. The Laurium Mining Co. continued development throughout 1912 on the Kearsarge lode. Preparations were made to resume operations at the LaSalle Copper Co., and shafts Nos. 1 and 2 on the Tecumseh tract were unwatered.

The New Arcadian Copper Co. sunk its shaft to a depth of over 250 ft. and, in cutting a station at that point, opened a copper-bearing lode of promise. Shaft sinking was also done by the New Baltic Copper Co. The shaft of the Oneco Copper Mining Co. passed the 1200-ft. mark; rifts were extended at the several levels.

R. M. Edwards succeeded Stephen R. Dow, as president of the klin Mining Co. The new combined air-and-steam-hoisting engine nto commission at the Franklin during the summer. The Quincy shaft was arranged to handle a large tonnage and the surface

equipment, a duplicate of No. 8, was started. No. 6 rock house was remodeled and increased equipment installed at No. 2 surface plant.

The Hancock No. 2 vertical shaft was sunk to a depth of 4000 ft. A series of copper-bearing formations was cut at various points from 3400 ft. down. A well-mineralized formation designated as the footwall lode was cut by the cross-cut from the eighteenth level. The surface equipment is complete and the property will enter the producing list in 1913.

At the Isle Royale, work was done on the Grand Portage lode with encouraging results. A new shaft was started on the main lode and railroad connections were made to afford shipping facilities to the Lake Milling, Smelting & Refining Co. mill, which will handle the increase in production; the Isle Royale mill is operating to capacity. The Houghton Copper Co. sank a winze about 200 ft. deep from the 620-ft. level drift and cut three copper-bearing lodes.

A slight curtailment was made in the rock shipment of the Superior property to the Atlantic mill and attention was given to putting the West lode in shape for production. Sinking was resumed at No. 2 shaft and railroad connections made to permit shipping to the Lake Milling, Smelting & Refining Co. mill. The Baltic company of the Copper Range Consolidated experienced a decrease in the copper content of the rock, but this was probably offset by a betterment in the Trimountain at depth. At the Baltic mill a low-pressure turbine was ordered to furnish electric power; Hardinge conical mills are also to be installed for regrinding the tailing.

Production from the Winona mine was increased; the company was handicapped by its inability to secure trammers. The second head at the stamp mill went into commission and Hardinge conical mills were installed.

The North Lake shaft-sinking operations were suspended shortly after the shaft was established in the ledge, pending the delivery of a hoisting engine. The South Lake shaft reached the Butler lode at a depth of about 110 ft. Indiana put its shaft down over 1200 ft. on its way to cut the felsite formation that revealed the remarkable cores about two years ago. The Lake company entered the producing list, sending between 300 and 400 tons of rock daily to the Trimountain mill. Adventure carried on exploratory work during the year. The Mass mill and railroad were overhauled and shipment to the mill aggregating about 700 tons daily was made from the Butler and Evergreen lodes. The No. 6 Victoria shaft was sunk about 1000 ft. Results at this mine were good.

At the White Pine property of the Calumet & Hecla company two shafts were opened and good ground was developed. The copper is

flaky and occurs in a sandstone formation; with improved milling methods it can be successfully treated. The favorable results led to the formation of the Chemago company to develop adjoining land and also to the preparation for resumption work at the Nonesuch property.

Montana.—The Butte district was the second largest producer next to Arizona in 1912; it ranks first however in total copper production. The Anaconda has the largest output of copper of any company in the world.

By R. R. Thayer[1].—There was a marked increase in general activity in the Butte district during 1912, occasioned by the higher prices received for the several metals. All of the companies operated with but few interruptions, and in consequence the metal output was greater than it has been for several years previous.

The Anaconda Copper Mining Co. was busy installing the new system of air hoisting, but it will take another year at least to complete the installation, and not until that time will the full benefits of the change be felt.

The Davis-Daly, East Butte, Butte & Superior and Anaconda, and in fact all of the operating companies, did the usual large amount of development work during the year, and the officials of the several companies expressed themselves as being well satisfied with the results. There is an unusual amount of activity in the eastern end of the district.

Duluth capital is developing a section in the northeastern portion of the district, while the Anaconda company is preparing to explore some of its property lying east of the Pittsburgh & Montana properties, now owned by the East Butte company.

A prophecy was made some years ago that in time Butte would become as important a factor in the production of zinc as it has been in the production of copper, and now it appears likely that the prophecy will be fulfilled. The Butte & Superior company is completing a concentrating plant, situated at its mine, which, according to reports, is effecting good recoveries, and it is stated that the mine is looking exceptionally well, so well, in fact, that an increase of concentrating capacity is contemplated.

The use of electricity for power has become more general throughout the district, and the Butte, Anaconda & Pacific Ry. is about ready to operate its trains by electric power, thereby effecting a material saving in operating expenses. This is the pioneer movement in railway electrification in the Rocky Mountain districts, but it is almost an assured fact that at least one of the transcontinental railroads will electrify in the near future, at least on the mountain divisions.

[1] President, Anaconda Copper Mining Co.

The cost of producing copper at all points in Montana increased somewhat during the last 6 months of 1912, due to an increase in the wage scale which was granted by the several companies on account of the better prices obtained for their output; but the advance in wages was general throughout all the copper-mining regions of the United States.

Anaconda Copper Mining Co.—The mines of the company produced during the year 4,576,289 tons of ore and 3668 tons of precipitates, or a total of 4,579,957 tons, hoisting through 22 shafts.

The reduction works treated for all companies during the year 3,880,203 dry tons of ore and other cupriferous material at Anaconda, and 1,189,039 dry tons of ore and other cupriferous material at Great Falls. Of this, 4,486,873 tons of ore from company mines, 581,032 tons of purchased ore, and 1338 tons of precipitates and cleanings from the old works were treated, from which there was produced 222,763,670 lb. fine copper, 9,702,605 oz. silver, and 52,564 oz. gold at Anaconda; and 71,710,491 lb. of fine copper, 1,312,132 oz. silver, and 8751 oz. gold at Great Falls; or a total production of 294,474,161 lb. of fine copper, 11,014,737 oz. silver and 16,314 oz. gold.

A great amount of experimental work has been done during the year, embracing the testing out of many concentrating machines, with varying success, and also a process for the reduction of slimes and tailings, which promises well. The process will be tested on a larger scale, and should it prove successful a complete installation will be made, which will mean a reduction in costs, and an increase in output of refined copper from the same tonnage of original ore treated. The process has been perfected by employees of the company. There is available at the Washoe reduction works many millions of tons of tailings, the accumulation of years of operation, all of which would be amenable to profitable treatment by the process, should it prove successful.

The Great Falls smeltery, built in the year 1889, became antiquated, and it was deemed advisable to erect a new smeltery, with the exception of the blast-furnace department, rather than to attempt to repair the old one. The erection will begin in the early part of the year 1913.

The greatest improvement made during the year was in the converting department, where a radical change was made in the size of the converter shells. The 12-ft. cylindrical converter, known as the "Great Falls type," from which excellent results were obtained, was supplanted by a converter cylindrical in shape, 20 ft. in diameter, which has been tested over a period of several months and found to give excellent results. The new smeltery will be equipped with converters of this type.

The development done during the year, in the form of drifts, cross-

cuts, raises, winzes, and shafts, amounted to 34.1 miles, and a large tonnage of ore in excess of the amount extracted was added to the reserves. The shafts of the different properties were sunk during the year to additional depths aggregating 4736 ft.

The Modoc, Anaconda, St. Lawrence, Steward and Tramway shafts were sunk to a depth corresponding to the 2800-ft. level of the High Ore mine, at which depth the new drain tunnels connecting all mines with the High Ore shaft will be established.

Contracts as to a sliding scale of wages were entered into with the labor unions. The Butte Miner's Union agreed for three years to an increase of 25 cents per day above minimum wage of $3.50 to correspond with electrolytic copper price bewteen 15 and 17 cents; also to 25 cents additional if above 17 cents. Dividends were $10,831,250 in 1912.

Tuolomne Copper Mining Company.—The production of the company during the year was 46,683 tons or ore, which contained 4,716,047 lb. of copper, 131,867 oz. of silver, and 259 oz. gold. The average copper content of first-class ore mined during the year was 7.35 per cent. The average of the silver was 3.38 oz. The average content of the second-class ore was 4.05 per cent. and of the silver 2.58 oz. per ton. The gross value of these metals was $739,196.08 and the net value after deducting smelter and freight charges was $415,528.55.

During the year, no ore was taken from the 2000-ft. level nor from the 800-ft. level, all of the production being from the 1200-, the 1600- and the 1800-ft. levels.

North Butte Mining Co.—The 1912 annual report of the North Butte Mining Co., Butte, Mont., states that 425,248 dry tons of ore were treated, yielding 26,480,123 lb. of refined copper, 1,377,468 oz. of silver and 1367 oz. of gold. This gives an average yield of about 62 lb. of copper per ton of ore. The net cost of copper was 9.652 cents per lb. of which mining and development was 6.977 cents; freight on ore, 0.197 cents; concentrating and smelting, freight and selling bullion 5.689 cents; construction, 0.08 cents and general expenses, 0.083 cents with a credit of 3.374 cents per lb. of copper for gold and silver. The mine was operated 342 days and hoisted an average of 1269 tons a day with 902.5 men, which is equivalent to 1.4 tons per day per man employed. The development work included in mining amounted to about 1 ft. for every 24 tons of ore mined.

East Butte.—The smelter turns out about 400,000 lb. of copper per month and its capacity is to be increased to 2,000,000 lb. The ore is obtained from the 800-, 1000- and 1200-ft. levels and averages more than 7 per cent. Cu.

*Nevada.*—The report of the Nevada Consolidated Copper Co. for

the year ended Dec. 31, 1912, shows that additions to the ore reserves have been made during the year, the estimate of total ore in reserve as of Dec. 31, 1912, being 38,853,551 tons with an average copper content of 1.67 per cent.

During the fiscal year the following dry tons of sulphide were mined and shipped to the concentrator: From the Eureka pit, 2,054,758 tons; Liberty pit, 170,748 tons; and from the Hecla pit, 371,485 tons, the average copper content of all this extraction being 1.603 per cent. From the Veteran mine, 253,365 tons, with an average copper content of 2.605 per cent. were extracted making a total of 2,850,356, with an average copper content of 1.690 per cent. sent to the concentrator.

The direct costs for mining at the pits, including charges of every description have been 17.35 cents per dry ton. Stripping costs have been reduced to 33.64 cents per cubic yard. Cost for mining carbonate ore was 68.80 cents per dry ton, as compared with 74.4 cents for the preceding year.

The Steptoe Valley Smelting & Mining Co's plant worked sucessfully during the year and showed improvements in all departments, except for the unfortunate occurrence of the strike. In addition to the treatment of the Nevada Consolidated ore, 133,933 dry tons from the Giroux Consolidated Mines Co. were concentrated and the concentrate smelted.

Although treating a lower grade of material the concentrator obtained better extractions, owing to improvements which had been foreshadowed in the last report. There were treated 2,852,515 dry tons of ore, with an average copper content of 1.692 per cent. The extraction of copper was 68.25 per cent. and the ratio of concentration 9.09. The assay in gold of this ore was 0.016 oz., and of silver 0.049 oz. Gold extraction was 45.84 per cent. and of silver 50.11 per cent. The average gold and silver recovered per ton of ore in cents was 16.48, and the average copper in the concentrate was 10.49 per cent.

All the reverberatory furnaces are now oil fired and their capacity has been greatly increased. Additions have also been made in the converting department and there are now two Peirce-Smith basic converters in which considerable improvements have been made in the way of operations. The production amounted to 63,063,261 lb. of copper for the year, and its total cost was 8.86 cents per pound.

Gross revenue includes 63,063,261 lb. copper, sold at 15.979 cents, $10,076,872, and for gold and silver produced, $521,278, a total of $10,598,150. Operating and other expenses, $7,316,231, leaving a profit of $3,281,919, to which is to be added $1,541,920, producing a net profit of $4,823,839 for the year.

Mason Valley Mines Co.—The tonnage smelted, during the year

1912 was 98,912 tons of Mason Valley ore, 142,910 tons of custom ore, and 15,768 tons of limestone. From the above there were produced 19,849 tons of copper matte containing 16,058,493 lb. of copper, 916 oz. of gold and 49,318 oz. silver. The development work accomplished during the year amounted to a total of 1391 ft. Electric power is secured from the Truckee River General Electric Co., and transmission is approximately 80 miles. All machinery at the mine is operated by electric power, and with the exception of a few days' shutdown, on account of the burning of one of the company's transformer stations, the supply has been satisfactory.

The smelter was blown in on Jan. 6, 1912, and one furnace has been in continuous operation since that time. The plant consists of two blast furnaces, which, it was estimated, would treat a minimum of 400 tons each of ore per day. These furnaces have exceeded this estimated capacity by approximately 100 per cent. and with the completion of enlargements now in progress, the plant will have a capacity of 1800 tons of ore per day. The Dwight & Lloyd sintering process has been used in handling flue dust, fine ore and concentrate. The two machines have a capacity of 200 tons of product per day. The installation of converters has now been decided upon.

Nevada-Douglas Copper Co.—Production during the year amounted to 120,908 wet tons, an average of 331.3 tons per day. In dry weight there were 106,483 tons which produced 9,020,640 lb. of copper, or an average of 84.71 lb. of copper per dry ton of ore. During the same period leasers shipped 551 wet tons. There was employed, in the extraction of this ore, a monthly average of 243 men whose daily wage averaged $3.41. The tonnage mined and shipped during the past year has been produced from all sections of the Ludwig and Douglas Hill mine.

The development accomplished by the company during the year amounted to 2087 ft. of sinking, 6128 ft. of cross-cutting, 4503 ft. of raising, and 8623 ft. of drifting, a total of 21,362 ft. of development.

The gross operating revenue of the company was $824,891, while operating expenses were $390,077, leaving a gross operating profit of $434,814. Deducting from this the expenses for mine depreciation and for fixed charges, amounting to $164,657, there remains a net profit of $270,157 for the year.

Giroux Consolidated Mines Company.—Shipments of concentrating ore were started in May, 1912, and production was gradually brought up to a minimum of 1200 tons per day. Total shipments for the year were: Concentrating ore, 140,877 tons; smelting ore, 410 tons.

August, September and December were the only months in which production came entirely from underground mining. Excluding ex-

traordinary development and construction at the property, the cost of production of copper for these three months was 10.8 cents per pound, or a net profit of $150,000 during that time. The Consolidated Coppermines Co., is a new corporation with an authorized capital of 1,600,000 shares at $5 par, which is to take over the Giroux, Coppermines, Butte & Ely and Chainman companies in the Ely district, by exchange of stock.

*New Mexico.*—The report of the Chino Copper Co. for the year ended Dec. 31, 1912, states that the total area now owned and controlled, in connection with the mill location, at Hurley, and the various water rights belonging to the company, contains 7996 acres. Of this total, 6600 acres are owned outright, the remainder being leased from the state and individuals.

The last annual report showed 54,970,646 tons of ore containing an average of 2.24 per cent. copper developed. Of this tonnage, about 60 per cent. was stated to be available for steam-shovel mining. Calculated upon the basis heretofore used of excluding lower-grade material, the ore reserves shown by this report would be something over 58,000,000 tons. By the application of a modified basis of calculation, this being the one upon which the engineers agree that the total developed tonnage can be most economically and profitably mined, the ore reserves amount to over 90,000,000 tons, containing an average slightly above 1.8 per cent. copper. Neither the tonnage nor the grade of it is stated in specific terms, because it is impossible, pending further experience, to determine exactly what angle of slopes will be necessary and safe in mining to greater depth. It is estimated that of the tonnage stated, about 80,000,000 tons of average grade, or nearly 90 per cent. of the total reserves, will be available for steam-shovel mining.

The total amount of material of all classes moved by steam shovel during the year was 2,850,464 cu. yd. Of this quantity, 2,223,678 cu yd. was waste, the difference, which was equivalent to 1,301,463 tons, being ore. Of this amount, approximately 200,000 tons were added to stockpiles at the mine, the remainder being sent to the mill.

The average cost of steam shoveling for the year was 29.14 cents per cubic yard in place, equivalent to 14.03 cents per ton; the cost of ore production alone was 16.52 cents per ton. No underground mining will be necessary for years.

The amount of stripping is covered by a charge of 30 cents per ton of ore produced.

From the Hearst section 2291 tons of 12 per cent. copper ore was shipped to El Paso. Such ore is encountered intermittently. The mill now consisting of five sections operated during the year; the operation was equivalent to three sections working continuously. 1,120,375

tons were treated, containing 2.077 per cent. copper. The recovery was 61.63 per cent. With some grades of ore a 74 per cent. recovery was attained for a time. Milling costs averaged 58.57 cents per ton, including the starting up, etc. The production was 28,684,208 lb. of copper in concentrates running 21.2 per cent. The ratio of concentration was 16.56 to 1. As much carbonate ore was present, it is expected to make 25 per cent. concentrate where this is absent. The average cost of producing copper from concentrate, was 7.69 cents per pound complete. The average price was 15.64 cents per pound of copper.

*Tennessee.*—The production of copper in the State is estimated at 18,500,000 lb.; the amount of ore treated by the two companies at Ducktown was about 603,200 short tons.

The Tennessee Copper Company produced last year 13,252,634 lb. of copper from its own ores and 4,406,423 lb. from custom ores; the silver recovery was 50,622 oz. and gold, 337 oz. The sulphuric-acid plant operated continuously, except 15 days during the summer, and produced 192,084 tons of acid. The company's bonded indebtedness was reduced to $1,200,000. Besides paying $150,000 on this account, $100,000 was added to the reserve for plant depreciation and $50,000 for a special depreciation fund, and $150,000 was added to the surplus reserve account.

The company is now producing about 500,000 lb. of copper per week from its own and custom ores, and about 600 tons of sulphuric acid daily, which is said to be the largest production of acid from any single plant. It is expected that the company will shortly be placed on a regular quarterly-dividend basis. The new management will also take up at once the matter of treating the Eureka ore on a commercial scale. In the Eureka mine, there is reported to be already developed 2,500,000 tons averaging 44 per cent. Fe, 36 per cent. S and about 1 per cent. Cu. This ore is to be treated primarily for its iron and sulphur and has been the subject of experiment for some time; it is now planned to erect an initial unit to try out the process suggested. This, if successful, will give the company a new product, a non-phosphorus iron ore, and may lead to an iron-furnace operation, if a ready market is not found for the intermediate product.

*Utah.*—The increase in production was due to Bingham, although the Utah Copper and the Highland Boy had to break a strike and were idle during September and October. The Tintic district was also a contributor to the increase and so were the San Francisco and other districts.

The copper era came in 1896 when Col. Wall first recognized the value

[illegible] per cent ore at Bingham in 1887, but the Highland Boy was first to

The district shipped ore to the value of $70,000,000 before this,

[illegible] Jordan alone having produced $18,000,000. The output of

Bingham to-day is estimated between 18,000 and 24,000 tons per day, the recoverable values being $160,000. The dividends during the past 5 years are estimated at $5,000,000 per year. The mine of the Utah Copper Co. has about 166 acres developed to a depth of 345 ft. Twenty miles of railroad, of which 1 mile is in tunnels, and 1/4 mile is steel trestles have been constructed and cost $3,000,000.

The report of the Utah Copper Co. for the year ended Dec. 31, 1912, shows that the total area of lode mining claims owned by the company consists of 740,394 acres, and other lands, in which is included Bingham Cañon lands and the land containing the Magna and Arthur plants amount to 5281.85 acres.

The length of tunnels, drifts and raises driven during the year 1912 was 35,473 ft., bringing the total length of all underground work at the end of the period up to 414,691 ft., or 78.54 miles. Of this total, a large quantity has been destroyed by steam-shovel work and by underground work, but the workings still accessible amount to 29 miles. The cost of underground development for the year amounted to 15.62 cents per ton on all ores mined from underground workings, and to 3.47 cents per ton on the total tonnage of all ores mined and shipped to the plant both from the underground workings and steam-shovel levels. Churn drilling cost 1.04 cents per ton on all ore produced. The total cost of both underground and surface development amounted to 4.51 cents per ton of ore mined. This cost was all charged against operations and is included in the per ton mining cost for the year.

Previous to Jan. 1, 1913, there had been developed 257,584,500 tons of ore classed as fully developed, and 80,116,324 tons as partially so. This tonnage includes about 28,800,000 tons of partially developed ore in the slopes of the steam-shovel workings. The average assay of the fully developed ore is slightly in excess of 1.60 per cent. copper, and the average of the partially developed ore is 1.16 per cent. copper, making the average assay of a total of both classes 1.50 per cent. copper. There was mined prior to Jan. 1, 1913, a total of 21,200,842 dry tons of ore, averaging 1.542 per cent. copper, and the total reserves remaining amount to 316,500,000 tons averaging 1.495 per cent. copper. The year's addition to reserves was 15,000,000 tons in excess of the tonnage mined.

The total amount of capping removed during the year was 4,676,568 cu. yd., the average rate being 389,714 cu. yd. per month. The average thickness over the entire ore-body corresponds to 177,467 cu. yd. of stripping per acre. The total amount of stripping removed from the property represents the equivalent of completely stripping 97.43 acres. The ratio of stripping to ore, both as to thickness and tonnage, within the limits of the fully and partially developed area, is

approximately 1 to 4. The ratio of stripping to ore in the slopes themselves will be considerably greater than 1 to 4, and therefore, taking the slopes into consideration, the actual ratio of stripping to ore, for the whole ore-body, will be somewhat higher than that stated, but in no event in excess of 1 to 3.

Underground mining operations were conducted at the Boston mine and the original Utah mine on the East Tunnel side of Bingham Cañon. It is not the intention to again do any underground mining in the original Utah area and it is purposed to discontinue underground mining altogether before the end of 1913. Of the total ore mined during 1912, 77.81 per cent. was obtained by steam shovels from the original Utah mine; 4.33 per cent. was mined underground in the Utah mine, and 17.86 per cent. was mined underground in the Boston mine. The average cost of steam-shovel mining for the year was 35.19 cents per ton, of which 8.84 cents represents charges on account of stripping expense and prospecting, leaving an actual working cost, including all extraordinary and general charges, except development and stripping expense, of 26.35 cents per ton. The average cost of underground mining at the Utah mine during the year was 74.93 cents per ton, of which amount 19.09 cents was the cost of underground development; while at the Boston mine, the average underground mining cost for the year was 65.56 cents per ton, which includes 14.39 cents covering underground development. The average cost of underground mining for the year at both mines was 67.39 cents per ton, of which amount 15.62 cents represents the cost of underground development.

During 1912 no additions were made to the equipment at the mines. No extensive additions were made at the Magna plant, excepting the enlargement and improvement of the coarse-crushing department, which work was commenced during the year with a view to increasing the capacity of that department for handling wet and frozen ore in winter weather. The Arthur plant has been entirely remodeled, the thirteenth and last section being finished early in September.

During the year there were milled at the Magna plant 3,454,800 tons of ore, while at the Arthur plant, the full capacity of which was not required, 1,860,521 tons were milled. During the summer months the Magna plant demonstrated its ability to handle over 12,000 tons of ore daily and the reconstructed Arthur plant has shown a capacity of over 8000 tons per day. With the coarse-crushing departments of both plants enlarged and improved so that they can handle full tonnage when the ore is wet or frozen, the combined economical capacity of both plants is therefore about 21,000 tons per day.

The average grade of ore treated at both plants was 1.3642 per cent.

copper. The average recovery for the year at the Magna plant was 66.03 per cent. and at the Arthur plant, 66.86 per cent. The average recovery at both plants was 66.32 per cent., corresponding to 18.09 lb. of copper per ton. The cost of milling at Magna was 39.64 cents and at Arthur, 45.18 cents per ton. The average cost of milling at both plants was 41.58 cents per ton; the average cost of both plants during the first 9 months of the year was only 35.46 cents per ton, as compared with 70.39 cents per ton at the last quarter, this difference being accounted for by the unsettled condition generally, particularly as regards labor, during that period. The milling cost is expected to be less than 30 cents per ton when conditions are such that the mills can be operated at full capacity of about 21,000 tons per day. The total gross production of copper contained in concentrate, for the year, was 96,175,090 lb. The concentrate produced averaged 20.75 per cent. copper. The average cost per pound of copper produced for the year, after making allowances for smelter deductions and applying credits for gold and silver recovered, but without crediting miscellaneous income, was 90.24 cents, as compared with 7.8655 cents for 1911.

If the miscellaneous income in Utah, including that from the Bingham & Garfield Ry., amounting to 0.243 cents per pound, were credited to the cost of production, the net cost per pound of copper for the year would be 8.781 cents. If, however, the total net earnings of the Bingham & Garfield Ry., in addition to other miscellaneous income in Utah, were used in this way, the amount would be 0.565 cents per pound, and the cost per pound of copper for the year, reduced by this amount, would have been 8.459 cents total cost. The net value of gold and silver recovered amounted to 0.957 cents per pound, as compared to 1.07 cents in 1911. For the months of July and August, those being the first ones in the history of the company in which full capacity was approximated, having averaged 19,616 tons per day of ore containing 1.4196 per cent. copper, there was produced not quite 22,000,000 lb. of copper, net, at a cost per pound, without the application of any credit from miscellaneous or railroad earnings, of 7.61 cents. If actual railroad earnings for those 2 months, together with other miscellaneous income in Utah, had been applied to reducing the expense of making copper, the cost would have been 6.89 cents per pound.

The average total cost of mining and milling for the year, exclusive of transportation charges, was 83.91 cents per ton. There is included in this cost a charge of 4.51 cents per ton, to cover the cost of churn-drill and underground development, as well as a fixed charge of 7.5 cents per ton for the retirement of stripping expense. The average cost for the year of mining, transportation and milling was, for mining, $0.4233;

transportation, $0.2848 and for milling, $0.4158; total, $1.1239 per ton milled. Further reductions in expense are expected, among which will be the lower cost of power, accomplished by the use of hydro-electric power from the Utah Power & Light Co., under a 25-year contract. Dividends paid during the year amounted to $4,729,747.

The Bingham & Garfield Ry. during the year handled 3,620,750 tons of commercial freight. Of this quantity, 3,381,161 tons were ore shipped by the Utah Copper Co.

The Ohio Copper Company began operations in August, 1912. During two 3 1/2-month operating periods 234,239 tons of 1.05 per cent. Cu ore were mined and concentrated. The contents of this ore was 234,439 lb. copper, 192 oz. of silver, and 379,875 oz. of gold. Mill mint No. 2 was dismantled and the Wall rolls removed. The rest of the mill averaged 2,000 tons of ore per day.

The annual report of the South Utah Mines & Smelters, Newhouse, Utah, for period Sept. 1, 1910, to June 30, 1912, states that 426,002 tons of ore were milled and 701.48 tons shipped at a cost of $2.2255 per ton. This cost was made up as follows: Mining, 83.45 cents per ton; milling, 67.23 cents; miscellaneous accounts,; 24.96 cents, and smelting, freight and refining, 46.91 cents per ton. From this cost a credit for gold, silver and other earnings amounting to 21.60 cents per ton was deducted, leaving a net cost of $2.0095 per ton.

Mining operation charges consisted of exploration, 4.61 cents, development, 3.87 cents; stoping, 39.13 cents; tramming, 15.76 cents; hoisting, 3.44 cents; timbering, 3.57 cents; and mine expense, 13.07 cents per ton. Milling operations include crushing, 4.55 cents per ton; milling, 62.16; and water supply, 0.52 cents per ton. Miscellaneous account was made up of hospital and claims, 0.09 cents per ton; insurance and taxes, 2.29 cents ore sampling; 0.83 cents; concentrates and ore freights, 21.26 cents; legal expense, 1.42 cents; and sundry charges, 1.23 cents per ton. The gold credits amounted to 11.47 cents per ton and silver 5.6 cents per ton.

The ore treated averaged 1.142 per cent. Cu or a total head contents of 9,727,235 lb. of copper and the net smelter returns showed 5,527,810 lb. of copper, indicating a net recovery of about 56.8 per cent. of the copper contents. The mill recovery was 59.09 per cent. concentrating at
-atio of 12.51 : 1. Concentrates averaged 8.438 per cent. Cu, 1.38 oz.
)8 oz. Au and 28.86 per cent. Fe per ton. The development
:ted of 4451 ft. of drifting, 614 ft. of raising and 17 ft. of sink-
·f 5082 ft. The cost per pound of copper was 17.17 cents.
ld, silver and miscellaneous earning make a net cost of
pound of copper.

The report of the Utah Consolidated Mining Co., covering the calendar year of 1912, shows a total of 183,386 dry tons of ore mined and shipped to the International Smelting & Refining Co., at International, Utah. These shipments included 159,143 tons of copper ore, averaging 2.146 per cent. copper, 0.077 oz. gold, 0.828 oz. silver; and 23,716 tons of first-class lead ore, averaging 19.974 per cent. lead; 0.073 oz. gold; 4.189 oz. silver; 0.820 per cent. copper; and 530 tons of lead concentrates, averaging 21.872 per cent. lead; 0.143 oz. gold; 5.432 oz. silver; 0.729 per cent. copper. The total product of the shipments was 6,506,814 lb. copper; 8,734,398 lb. lead; 230,004 oz. silver; 14,042 oz. gold.

The ore remaining in sight is given as 251,500 tons of copper ore, averaging 1.9 per cent. copper; 0.04 oz. gold and 0.58 oz. silver, together with 24,100 tons of first-class lead ore, averaging 14.96 per cent. lead; 0.055 oz. gold; 3.51 oz. silver and 0.97 per cent. copper. In addition there are 12,000 tons of low-grade lead ore, which will require concentration. Dividends of $450,000 were paid during the year.

The Bingham Mines Company produced 3,731 oz. of gold, 225,763 oz. of silver, 3,770,320 lb. of lead and 1,427,780 lb. of copper. Net earnings average $12,000 per month.

The Tintic district shipped all told 9,620 cars of ore in 1912, but the amount carrying copper is not separated.

*Washington.*—The production was chiefly from Stevens County, where 37,000 tons mixed ores yielded 1,007,076 lb. of copper, 1,152 oz. of gold, and 233,535 oz. of silver.[1]

The Tacoma smelter received some copper ores from White horse.

*Other States.*—The production of two states, Pennsylvania and Maryland, is estimated[2] at 594,022 lb. produced from 255,200 short tons of ore. Virginia produced about 113,000 lb. of copper and North Carolina 76,000 lb.

## Foreign Countries

The productions as shown by the table for the world on page 168, have not increased materially excepting for South America and Russia.

*Africa.*—The first important shipment from Katanga, Belgian Congo, was made in 1909, when 24,504 lb., valued at $3325, were shipped. In 1910 and 1911 the shipments amounted to 336,708 lb. and 2,484,636 lb., valued, respectively, at $17,404 and $367,252. Although copper exists in large quantities in Katanga and in smaller amounts in other parts of the country, the cost of extraction and the long rail transport to the

[1] Preliminary figures *U. S. Geol. Surv.*
[2] *U. S. Geol. Surv.*

sea make it extremely doubtful if Kongo copper will seriously compete in the world's markets. Raw copper is shipped to Belgium. The Katanga district is now connected with the east coast by railway via northwestern Rhodesia, Victoria Falls, Bulawayo, Salisbury and Beira. Capetown can also be reached by railway from Bulawayo via Kimberley.

One furnace of the Union Miniere du Haut Katanga made intermittent campaigns early in 1912, and also in 1911. The Star of the Congo mine is to be worked below the water level. The ores are highly siliceous and oxidized. Coke is expensive; that from the Wankie colliery in South Rhodesia has been found satisfactory. Copper costs £30 landed in London. To November, in 1912, 7660 tons of ore were smelted for 1038 tons of blister copper of 94 per cent. To this date the total ore smelted was 28,054 tons, yielding 3036 tons of blister.

In the Star of the Congo mine there are said to be developed 350,000 tons of 15 per cent. ore and 1,500,000 tons of low-grade ore. The railway will be completed to the Kambove mine by the end of the year. In this mine 2,000,000 to 3,000,000 tons are developed. The question as to whether these oxidized ore-bodies are due to concentration by descending waters and are merely superficial or whether they are the capping of sulphide deposits, strangely enough, does not appear to have yet been solved, or if solved the information has been kept secret. There has been ample time to test this matter with a drill.

A rough-washing plant is being erected which will eliminate much silica and alumina from the furnaces and reduce the consumption of coke about 1 ton per every ton of copper produced.

The reduction process by which the copper in the low-grade ore was to be reduced with coal in a reverberatory furnace, and the resulting copper concentrated, has been tried on a small scale without success so far. In Ugine (Savoie), France, about 50 tons of ore have been smelted in a makeshift steel furnace by electricity and future experiments with a properly designed furnace are to be carried out. If successful a subsidiary company will supply power from the falls near the mine for this process.

The Bwana M'Kubwa copper mine, in northwest Rhodesia, promises soon to become a producer as well as the Kansanshi mine. Above the 350-ft. level there are in sight 120,000 tons of 14 per cent. ore, mostly lumps of malachite in gossan and 700,000 tons of 5 per cent. ore. As soon as rail freights are reduced, it is the intention to erect a large plant to operate the Siemens-Halske leaching and electric precipitation process, which has given good results experimentally. Meanwhile a rough, wet-concentrating plant is ordered to beneficiate the high-grade ore for export.

According to the report of the Campagnie Miniere du Congo Francaise for 1912, boreholes have shown that the Mindouli deposit will yield 6000 tons of copper. The poorer grades of ore will eventually be treated before shipment, but at the present only the richer ore is shipped. In 1912, 1735 tons of ore realized £64,800. The projected government railway from Brazzaville to the Atlantic will pass through the property.

The Otavi mine is no longer the only producing mine in German southwest Africa. The Khan copper mine,[1] on the Khan River, has entered the producing stage after having been opened to a depth of 160 meters. The result of the development work is stated to have been encouraging. The visible ore reserve guarantees considerable working profits and a long life. An up-to-date reduction plant is being erected, to treat 50 tons of ore per day, which is expected to start work early in 1914. The water required for the works is pumped up from the Khan River through a pipe-line of a length of 18 km. Electric power will be generated at a central station. The works are connected by private line with the railway at Arundis.

The Cape Copper Company has decided on account of diminished output of the Okiep to do all its smelting at the Nababeep works, where the output has been maintained.

For the developments of the Messina Company Transvaal, see MINERAL INDUSTRY, XX, p. 194. The Camp Bird, Ltd., owns a large interest in this undertaking. It is estimated that the ore reserves are 170,000 tons of 10 per cent. Cu ore. Connection to the Selati railway will be completed early in 1913.

Shipments of copper from Capetown in 1912 were valued $2,687,014.

*Argentina.*—In spite of lack of development and exploration, the ore deposits promise to be a factor in the world's copper production. The Famatina Development Corporation (authorized capital $3,500,000) works the mines at Upulungus and at San Pedro. A 200-ton smeltery, treating 3000 tons per month recently, operates at Santa Florentina, near Chilecito. For calcining, one Brown mechanical roasting furnace is used. Two 18-ft. 6-hearth roasting furnaces of the McDougal type, similar to those used by the Cerro de Pasco Company in Peru, have been ordered. There is also a Yeadon briquetting plant in which the fine flue dust from the smelting works is mixed with roasted ore, slaked lime being added as a binder. Flux is obtained from a near-by limestone quarry, with some brought in from Cordoba, and the company has a sufficient supply of quartz on its own properties. Assays of regulus from the smeltery showed 61.24 per cent. copper, 255.3 oz. silver and 4.7 oz. gold per ton.

[1] *Min. Journ.*, Mar. 15, 1913.

Since April, 1911, however, all of the product has been in the form of blister copper.

In order to develop the Famatina mining district, the government conducts, as part of the existing railway system, a 22-mile aërial tramway; the chief freight is copper ore which comes down at the rate of 40 tons per hour during the day.[1]

The lodes range from 1 to 6 ft. thickness. The copper content is from 4 per cent. to 14 per cent., and sulphur from 16 to 38 per cent. and iron 18 to 20 per cent. Gold averages 1.3 oz. and silver 71 oz. per ton.

*Australia* (By W. P. Geary[2]).—The production for 1912 was stimulated to some extent by higher prices. The maximum production, excepting 1912, was in 1907 and was the outcome of a gradually extending movement in the direction of mining the industrial metals as opposed to the winning of gold and silver. In 1902 Australia's production of the red metal was only 28,600 tons. Australia has nearly doubled her winnings. Statistics will probably prove that there are no more men engaged in the industry to-day than there were 10 years ago, which suggests, of course, that the increase has been brought about by the treatment of higher-grade ores.

It could be said that the increased production when compared with 1902 was attributable to the developments that have taken place in Queensland. During the decade Queensland's production has risen from virtually nothing to 25,000 long tons for the current year. The so far unprofitable Chillagoe scheme, though it is only responsible for a small proportion of the State's output, may, perhaps, be given credit for inducing public interest in copper ventures in the northern state. The wise government which owns the railways took care to see that the State did not sink into disrepute by the comparative failure of the Chillagoe mines. By railway encouragement the government induced healthy settlement at Mount Elliott and Hampden.

The Cloncurry field, embracing as it does a huge area of cupriferous country, will be responsible for about 12,000 tons in 1912. Mount Morgan will barely reach the 10,000-ton mark. Next year should witness an improvement in the figures of this property, and the following year, when the new plant which R. Sticht, of Mount Lyell, is designing, is running at its top, there is no reason why Mount Morgan should not turn out 1000 tons per month comfortably.

New South Wales, which is the parent State of the Commonwealth, will probably turn out its usual 9000 to 10,000 tons. The apathy with which the mining industry is regarded in New South Wales is astonishing

[1] A. Tupper, *Eng. and Min. Journ.*, Sept. 28, 1912.
[2] Department of Mines, Sydney, N. S. W.

when one realizes its enormous potentialities. Given one-half of the railway encouragement which Queensland is affording its mines, the copper propositions of New South Wales would, in practically no time, raise the output from 10,000 tons per annum to 20,000 tons. Given an equal share of railway facilities, New South Wales could, from its already proved resources, turn out consistently 40,000 tons per annum.

In south Australia, Wallaroo & Moonta turned out copper at the same old rate of about 6000 tons per annum; while Victoria has practically no copper production worth speaking of. Strangely enough, the most ready financial encouragement to the mining industry in all of the states where anything progressive is happening comes from South Australia and Victoria.

Western Australia cannot yet be spoken of seriously in a copper-producing sense. The properties of Ravensthorpe, which last year were making blister copper, have passed into the hands of tributors, and they send whatever ore they mine to the Port Kembla refinery, in New South Wales.

In Tasmania, Mount Lyell has done its best to live up to the production of 7000 tons of copper per annum, but the recent fire and loss of life, which necessitated closing down almost entirely for a time, will probably result in a shortage in Mount Lyell production of approximately 1500 tons.

Some of the old New South Wales ghosts, notably Nymagee, Burraga, Cadia and others of less importance, are receiving further capital, and, if the market holds good, 1913 may witness an appreciable increase in the Australian output.

The following table gives statistics as nearly as they can be ascertained for Australasia. The combined exports for the Commonwealth in 1912 consisted of 12,519 long tons of ore valued £96,633; 468 tons of concentrates valued £4213; 19,630 tons of copper in matte valued £1,411,244; and 24,209 tons of ingot copper valued £1,803,103. The estimate of production for Australasia by Merton & Co. for 1912 is 47,020 tons, compared with 41,840 in 1911. Aaron Hirsch and Sohn credit Australia with 45,500 tons in 1912 and 44,600 tons in 1911. Benjamin Magnus, manager of the Port Kembla Refinery, N. S. W., describes the relations of copper plants and gives capacities,[1] etc. The two prominent refineries are the Electric Refining & Smelting Co., of Australia, and the Great Cobar Copper Co. The former produced 18,000 long tons per annum, and the latter about 5,000 tons. The production of the former in 1912 is estimated at 16,500 tons.

New South Wales.—The mines at Cobar produced copper valued

[1] *M. S. P.*, Jan. 4, 1913.

PRODUCTION OF COPPER IN AUSTRALASIA.
(In tons of 2240 lb.)

| Year. | New South Wales. | | | | Queensland. | | South Australia. | Tasmania. | | | | Western Australia. | | Combined value. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ingots, Matte and Regulus. | | Ore. | | Copper, Tons. | Value. | Copper, tons. (a) | Value. | Blister copper. | | Copper ore. | | Copper ore, tons. | Copper (b) tons. | |
| | Tons. | Value. | Tons. | Value. | | | | | Tons. | Value. | Tons. | Value. | | | |
| 1905 | 7,962 | £522,276 | 630 | £5,127 | 7,221 | £503,547 | 6,548 | £426,511 | 8,610 | £704,287 | 1,151 | £52,939 | 2,389 | ..... | £16,266 |
| 1906 | 8,964 | 781,645 | 791 | 7,882 | 10,077 | 916,546 | 8,208 | 718,609 | 8,708 | 862,444 | 2,234 | 72,480 | 7,430 | ..... | 50,337 |
| 1907 | 8,963 | 716,759 | 1,135 | 11,015 | 12,756 | 1,028,179 | 7,931 | 690,000 | 8,247 | 832,691 | 788 | 36,975 | 3,727 | 1,602 | 203,376 |
| 1908 | 8,679 | 496,564 | 392 | 6,248 | 14,961 | 893,535 | 5,628 | 338,000 | 8,833 | 603,063 | 1,185 | 6,588 | 2,503 | 479 | 57,091 |
| 1909 | 6,857 | 423,612 | 109 | 1,095 | 14,494 | 853,196 | 5,697 | 334,584 | 8,638 | 586,419 | 1,588 | 21,619 | 6,939 | 833 | 104,644 |
| 1910 | 8,435 | 450,491 | 4,455 | 35,766 | 16,387 | 932,489 | 5,102 | 306,120 | 8,193 | 553,822 | 671 | 13,150 | 6,309 | 1,281 | 95,928 |
| 1911 | 10,618 | 578,198 | 1,482 | 11,904 | 20,384 | 1,151,351 | 5,922 | 332,500 | 6,022 | 385,797 | 2,286 | 22,862 | 9,825 | 829 | 78,364 |
| 1912 | 8,990 | 560,025 | 2,044 | 19,766 | 23,120 | 1,698,280 | 6,295 | 461,500 | 5,136 | 430,965 | 1,392 | 9,479 | 13,607 | 1,703 | 120,168 |

(a) Small amounts of copper ore, and sulphate not included here. (b) Ingots and matte.

£410,155, an increase of nearly 11 per cent. The output of the Great Cobar mine totalled 6650 tons against 6548 tons in 1911. Much ore from the smaller mines of the district were treated at the company's smelter.

The Nymagee mine increased its production. The Crowl Creek mine was re-opened. The Mount Hope remained closed down in 1912. At the Bogan River mine (Dandaloo division) the output was less than in 1911. It is intended to commence smelting operations at the Mount Royal mine early in the new year. The Carolina mine produced £8060 in value and prospects are promising. The Grafton Copper Company's mine at Cangai produced satisfactorily. The Kyloe, at Adaminaby, continues to furnish good yield; the flotation process is successful for this ore. The Lloyd copper mine resumed operations; this mine closed in 1909 on account of expense of fuel. Production will probably increase in 1913.

The Electrolytic Refining and Smelting Co. of Australia, Ltd., at Port Kembla, produced 16,888 tons of electrolytic copper in 1912; the larger proportion of this was from imported blister copper The disaster at Mt. Lyell, Tasmania, prevented a larger production. The number of men employed in New South Wales was 2384, and 243 tons of mineral were mined per person.

Queensland.—The chief production of copper is from the Mount Elliott and the Hampden smelters in Cloncurry. The former produced, in 1912, 6690 tons of copper, 11,766 oz.

of gold and 12,014 oz. of silver from 54,531 tons of ore. The Hampden smelters completed toward the end of July, 1912, produced 2392 tons of copper, 850 oz. of gold and 24,930 oz. of silver.

At the Mount Elliott mine the faces are looking well. The Hampden mines await the completion of the Malbon to Duchess Railway, and the company is pushing to completion the reduction works at Freizland.

The Elliott and Hampden Companies have not amalgamated their interest. They are rivals in securing promising properties. The former has acquired the Hampden Consols mine, and the latter the Wee McGregor mines.

The northern portion of the Queensland copper belt, when the Mount Cuthbert railway will make transportation easier, will attract attention. The prominent mines are the Mount Cuthbert and the Mount Oxide. In the former, ore reserves in September, 1912, were 150,000 tons of 8 per cent. copper ore, carrying £17,500 worth of gold, and 70,000 tons of 4 per cent. copper ore, carrying £2325 of gold. Allowing 90 per cent. recovery and 80 per cent. recovery from the low-grade ore, this equals 13,400 tons of copper. The Mount Oxide mine, 160 miles northwest from Cloncurry, has produced some high-grade ore and is being developed.

In the Chillagoe district the Lady Jane mine has 50,000 tons of copper ore locked up in the fire area. Probably in 1913 the chief producer will be the Mammoth Copper Mines, Ltd., at Cardross, because the output of the Mungana has been greatly reduced. The company hope to keep their 60-ton furnace supplied with ore, part of which will come from the Klondyke copper mines.

In the New Einasleigh copper mine, an ore-body 25 ft. thick, assaying from 5 to 6 per cent. copper, has been intersected 100 ft. below the No. 4 level. The main shaft is being sunk at 500 and 600 ft. and no doubt the future of the mine is assured.

For nearly the whole year one furnace at Chillagoe has produced copper matte which is converted. The new blast-furnace at Cardross started in October, 1912, and the matte is sold in Chillagoe.

At Mount Perry the New Queensland Copper Co. has been assisted by the government, and an extensive development scheme is being prosecuted. The production of copper, gold and silver from these mines is increasing. Smelting operations suspended during the early part of 1912 were resumed, and 421 tons of copper, 19,566 oz. of silver and 260 oz. of gold were produced from 4120 tons of ore. The company employs about 226 men.

The ore from the Many Peaks mine in 1912 is of lower grade, but the output increased, being 100,339 tons of ore. This yielded 1473 tons

of copper and 775 oz. of gold. A mine fire prevented extensive work, but an ore-body between the 470- and 570-ft. levels was developed.

The Mount Morgan half-yearly report, ending Nov. 30, 1912, states that the smelter in commission 7 years cannot be made suitable for pyritic smelting. The expense of a new plant for this purpose will be £150,000. During the half year, of 113,061 tons sent to the smelter, 62,408 tons came from high-grade ore reserves and 24,280 tons were low-grade ore not included in reserves. The net reserves on Nov. 30, 1912, were 1,433,000 tons high-grade ore and 1,997,000 tons medium-grade. At the Many Peaks mine 53,064 tons of 1.64 per cent. Cu. ore were produced. The freight rate is high and almost prohibitive. The ore assays 0.15 oz. gold per ton, whereas the Mt. Morgan ore runs 3.49 per cent. copper and 9.11 oz. gold.

According to figures given in the report of the Mount Morgan Gold Mining Co., Mt. Morgan, Australia, for the year ended May 31, 1912, the total dividends paid since the formation of the company in July, 1886, to date are equal to approximately 44 per cent. of the total proceeds. Expenditures on plant and machinery account are equal to about 4.56 per cent. of the total proceeds from metal, while depreciation charged against this account amounts to 1.44 per cent.; wages and contracts have constituted almost 29 per cent. of the total proceeds. For the year materials handled consisted of 166,499 tons of auriferous copper ores, etc., 91,946 tons of Many Peaks ore, 93,413 tons of siliceous sulphide ore, 64,056 tons of limestone flux, 367 tons of ironstone flux, 222,446 tons of waste from open cuts, and 8752 tons of waste rejected underground, a total of 647,488 tons of material handled. About 8.5 tons of overburden or waste was removed in the open cuts for every ton of ore secured, while about 3.7 per cent. of the tonnage mined underground was rejected as waste. To produce 1 ton of blister copper in the reduction works it required 25.27 tons of Mount Morgan ore, yielding 2.71 per cent. copper; 13.95 tons of Many Peaks ore, yielding 2.25 per cent. copper; 9.72 tons of limestone flux; 0.05 tones of ironstone flux; 1.88 tons of converter lining and 4.39 tons of coke. During the preceding year it required 26.18 tons of Mount Morgan ore, yielding 3.01 per cent. copper; 8.15 tons of Many Peaks ore, yielding 2.26 per cent. copper; 12.56 tons of limestone flux; 2.45 tons of ironstone flux; 1.58 tons of converter lining and 4.52 tons of coke to produce 1 ton of blister copper.

The record of the mine since 1886 up to the end of the company's last financial year is as follows: Total value of proceeds (metals won), £18,001,591; total expenditure, £9,982,842; total dividends to Jan. 2, 1913, £8,029,166/13/4.

South Australia.—The production at the Wallaroo & Moonta Mining & Smelting Co. in the last 3 years was as follows:

| | 1910. | 1911. | 1912. |
|---|---|---|---|
| Refined copper (tons) | 4,855 | 6,079 | 6,287 |
| Silver (oz.) | 2,011 | 1,400 | 2,045 |
| Gold (oz.) | 1,296 | 1,222 | 1,757 |
| Bluestone (tons) | 210 | 182 | 102 |
| Sulphuric acid (tons) | 4,486 | 4,627 | 5,095 |

The cost per ton of ore treated in 1912 was 40s. 7.5d., an increase from 37s. 10.2d. in 1911. A flotation plant at the Moonta mines is to be in operation in 1913, in connection with the Richman's plant. The proper oxidation of the slimes is said to have increased the copper produced nearly 700 tons, and at the same time reduced the cost of treatment.

On both lodes large amounts of tailings are stored and will be treated. At the Wallaroo, 200,000 tons of material will probably yield 1000 tons of copper per year. On the Moonta, 600 tons of copper per annum can be obtained for 5 years. The available ore in the mines is now estimated at 40,000 tons of 2 to 4 per cent. Cu. At the Wallaroo the deeper levels retain their productiveness. The outputs of the mines were 417 and 2,116 tons, respectively, for 6 months, ending June 30, 1912. During 1911 a total of 58,516 tons of material was smelted. Converters were installed and the old reverberatories dismantled.

A report on the Yelta mine[1] states the following: The ore reserves, including the southern shoot which has not been depleted, are about 6313 tons of 5 per cent. copper; most of this ore is between the 720-ft. and 462-ft. levels. The smelting plant consists of two 36-ft. by 8-ft. 6-in. blast-furnaces 17 in. high. It is proposed to use a moderate blast and 10 per cent. limestone on the charge, producing a 30 per cent. matte and a slag 42 per cent. silica and 40 per cent. FeO, and 4.8 per cent. $Al_2O_3$. Work done previously in smelting 55.6 tons per day in one furnace made a 28.33 per cent. matte and a 0.3 per cent. copper in the slag. The cost of smelting is figured at 11.4s. per ton of ore; the total cost per ton of ore cannot be taken as less than 35s.

The report of the manager, Frank Richards, on the Parametta and Yelta copper mines, shows that though smelting had not commenced by July, 1912, much development had been done and the mine unwatered to the depth of 1080 ft. The Wandilta mine has been developed, and the lode cut 235-ft. depth opened up in 1912. Mr. Conder does not think payable ore will be found.

The Utica copper mine lies 6 miles southeast of the Burra Burra

[1] Hartwell Conder, M. A., South Australia *Review of Mining Operations*, No. 16, to June 30, 1912.

copper mine. Samples show from 2 1/2 to 25.3 per cent. copper in the ore, which is very pockety, the minerals being azurite, chalcocite and malachite in quartz.

The copper sulphate produced in south Australia was as follows: 1910, value £9350; 1911, £11,103; in 1912, £10,192.

Tasmania.—The Mt. Lyell Mining & Ry. Co. reports, for the half-year ended Sept. 30, 1912, a production of 3161 long tons of blister copper, assaying: Cu, 98.82 per cent.; Ag, 67.47 oz.; Au, 1.365 oz. The profits were £106,749, and dividends of £75,000 were paid.

From the Mt. Lyell mine, 96,247 tons of ore were extracted, and reserves (not including the South Mt. Lyell ore-body) then stood at 2,361,182 tons, carrying: Cu, 0.532 per cent.; Ag, 1.96 oz.; Au, 0.027 oz. The ore extracted from the North Mt. Lyell mine was 58,913 tons, and the reserves were increased by 60,390 tons, standing at 1,083,752 tons, at Sept. 30, 1912, carrying: Cu, 6 per cent.; Ag, 1.33 oz.; Au, 0.005 oz. From the Chester mine 6748 tons of pyrites were extracted for the Yarraville and Port Adelaide Chemical Works. The Mt. Lyell Comstock Copper Co.'s property, toward which the Mt. Lyell ore-bodies seem to trend, was purchased.

The reduction plant smelted 157,167 tons of company ore, 46 tons of purchased ore, 83 tons of metal-bearing flux, and 8894 tons of returns, producing 7545 tons of 45.95 per cent. matte, from which 3161 tons of blister were recovered.

The fire at the North Mt. Lyell mine occurred on Oct. 12, 1912, after the period covered by this report.

Victoria.—The copper produced in 1911 was from 1116 tons of ore, mined by the Gippsland Copper, Platinum and Gold Mining & Smelting Company, near Walhalla. This resulted in 91 tons of matte containing 36 tons of copper, 653 oz. of silver, 55 oz. of gold and 184 oz. of platinum.

*Austria* (Official report 1911).—Of twenty-eight copper mines, eleven were in operation during 1911. These employed 772 persons and produced 10,974 tons, 37 per cent. more than in 1910. Of this tonnage the state mines, four in number, in the Tirol, produced only 150 tons, employing about eighty-five men. The value of all ore produced in Austria at the mines is stated as $18.40 per ton; ore produced by the state mines was valued at $27.80 per ton. No copper is produced in Bohemia, but 130 tons of matte and speiss resulted as a by-product of the lead smeltery Karoli-Borromai at Pribram. In the province Salzburg the principal production of ore takes place, but there is only one smeltery, that of the Mitterberger Kupfer-Aktiengesellschaft at Auserfelden. This company produced from 12,365 tons of ore, valued $247,300, 1470 tons copper valued $389,500; 23 tons of electrolytic copper and 12 tons copper

sulphate, the latter worth $280 per ton. No nickel salts were produced and no nickel-bearing residues, of which a few tons are on hand since 1907, were smelted. The fuel used at these works was as follows: 2825 ton coke, 553 tons anthracite, 178 cu. m. of charcoal. The fluxes were 1616 tons of lime and 1,192 tons of quartz. The number of men employed was 132. The production for the year, of electrolytic copper, remained in stock and no copper whatever was exported.

In the Tirol, the State Smeltery at Brixlegg produced 267 tons of copper, and 755 tons of copper sulphate, the latter worth $92 per ton.

*Belgium.*—Copper is recovered at the sulphuric acid works from cupriferous pyrites. The cement-copper, containing from 75 to 90 per cent. pure metal, is largely exported. The production of copper sulphate, which is made in five factories in Belgium, is about 2500 tons per year, and is used in France in the vineyards.

*Bolivia.*—The following figures of the output are calculated on barrillas (dressed ores containing chiefly metallic copper) with an average content of 80 per cent. Cu:

| Year. | Weight in kilograms. |
|---|---|
| 1908 | 2,877,605 |
| 1909 | 3,096,605 |
| 1910 | 3,211,987 |
| 1911 | 2,950,024 |
| 1912 | 4,681,374 |

The increase in the 5 years is 1,803,769 kg., equal to 62.7 per cent. In the Corocoro district two mines produced 5,000,000 lb. per year.

*Bulgaria.*—The most important copper deposit in Bulgaria[1] is the Plakalnitza, near Vratza. The mine is 220 ft. deep, and the output 60 tons per day of ore, averaging 5 to 7 per cent. copper. The ore is smelted at Elisena, in two operations, to a 55 per cent. matte, of which 7 tons per day are produced. A concentrator has been installed to separate the increasing quantities of galena. Other deposits in the district are all of the same type and resemble the complex ores of Upper Silesia.

*Canada.*—There is no recovery of refined copper, but the copper contents of smelter products was officially reported as 58,405,910 lb. in 1912, as compared with 29,855,868 lb. in 1911. Copper sulphate, chiefly by-product from lead refineries, amounted to 87,110 lb. in 1912, and 197,187 lb. in 1911. The total copper contents, including ores exported, was 77,775,600 lb. in 1912, as against 55,648,011 lb. in 1911.

The exports in 1912 were: copper, fine in ore, etc., 76,542,643 lb., valued at $8,800,276, and copper black or coarse and in pigs, 1,945,921 lb., valued at $236,212. The total imports of copper in 1912 were valued at $7,052,534.

[1] H. K. Scott, *Bull.* 103, *Inst. of Mining and Metallurgy*, April 17, 1913.

Quebec province is credited with a production of 3,225,523 lb., as against 2,436,190 lb. in 1911, the increase being due to the increased production from the pyritic ores of the Eastern Townships. Ontario's production in 1912 was 22,250,601 lb., as compared with 17,932,263 lb. in 1911, being mainly derived from the nickel-copper ores of the Sudbury district. Apart from the copper shipments from Dane, the most interesting occurrence was the payment made for copper in shipments from the Cobalt camp. British Columbia had a record output of 50,526,816 lb., having had a year of uninterrupted smelter operation free from strikes and other disturbances. From the Yukon the Pueblo mine was a heavy shipper.

The most important camp in Canada produced up to July 1, 1910, more than 7,000,000 tons of ore. The ore-bodies[1] occur in a mineralized zone of the Brooklyn limestone, whish is replaced by epidote and garnet. The Brooklyn formation succeeds the Knob-Hill group, which consists of various igneous rocks and some sediments of limestone. The extensive granodiorite intrusions are widely developed and supposed to be of Jurassic age. The ore-bodies range from lenses 100 ft. by 20 ft. to 2500 ft. by 900 ft. by 125 ft. The latter is the maximum dimension, as shown in the Knob-Hill Ironside mine. The ore is uniform with finely disseminated chalcopyrite, with pyrite and hematite, in a gangue of epidote, garnet, quartz, calcite and chlorite. Masses of magnetite occur along the boarders. The values are in the chalcopyrite, and the ore averages 1.2 to 1.6 per cent. copper, with gold and silver about $1.00 per ton.

The Granby Consolidated Mining, Smelting & Power Co., for the year ended June 30, 1912, deducting depreciation on works and securities, had a shrinkage of surplus of $17,183; the working expenses of mines and smeltery, freight, refining, and selling, amounted to $2,128,211; foreign ore purchased to $163,170; while metal sales brought in $2,874,760; leaving an operating profit of $583,379. However, a deduction of $600,562 was made for depreciation on works and securities.

At Phoenix and Grand Forks, the mines and smeltery were down for 4 months because of lack of coke. No new ore-bodies were discovered at Phoenix, but the known bodies were further developed, and the company closes the year with a total of 6,433,418 tons of ore in sight, which may be expected to carry about 1.25 per cent. of copper, 0.29 oz. of silver, and 0.043 oz. of gold per ton.

At Hidden Creek, development has gone steadily ahead, and over $200,000 has been expended in work preliminary to the construction of a smeltery. Prospecting has been carried on in the country surrounding

[1] O. E. Le Roy, "The Geology and Ore Deposits of Phoenix Boundary District, British Columbia." Mem. No. 21, Geol. Surv. Branch, Dept. of Mines, Canada, 1912.

Grand Forks and Phoenix for a radius of 200 miles, but the apparently meritorious claims are too inaccessible.

There were 13,231,121 lb. of copper produced, 225,305 oz. of silver, and 33,932 oz. of gold, from 721,719 dry tons of Granby ore and 17,800 tons of outside ore smelted. The mining cost, including development, was $0.771 per ton. The cost per ton, allowing for all expenses except depreciation, was $2.90, the cost per pound of copper was $0.111.

The Hidden Creek mines are stated to have reserves of 5,000,000 tons of 2.2 per cent. copper, with $1.00 gold and silver values; equipment and smelter will cost $1,600,000.

The report of the British Columbia Copper Co., Ltd., covers 13 months, including December, 1912. During that period the smeltery treated 740,589 tons of ore, of which 443,022 tons were derived from the company's mines; 410,686 tons came from the Mother Lode mine; there was produced 11,146,811 lb. of fine copper; 142,025 oz. of silver; 25,863 oz. of gold. The company hopes to obtain a good tonnage of concentrating ore from the Princess camp, where six groups of mines were acquired.

A cost of 56.58 cents per ton, f.o.b. cars, was obtained at the Mother Lode. The same methods of stoping were continued, and the end of the year saw about 5000 holes ready to blast. There was no increase in reserves and the average grade remained below the normal of former years. The mine in the Wellington camp was closed in June for the time being. The ore in the Lone Star and Washington mine is refractory, although a large tonnage is developed. The mine was worked for 3 months in the summer only. Conditions at the Napoleon and Queen Victoria mines are satisfactory. The cost of production was 12.85 cents per pound of copper. The cost per ton from ore in place to sale of the contained metal is given at $2.46.

The proceeds of metal shipments for the year were $2,483,664, and miscellaneous earnings were $7614, from which are deducted operating expenses of $1,570,205 and ore purchases of $495,087, leaving earnings of $425,986. The latter is said to have 50,000 tons of low-grade ore blocked out and can ship 100 tons per day.

The Canadian Copper Company resorts to heap roasting at its Copper Cliff smeltery. The smelter fume issue made its appearance in 1912 in the form of a lawsuit. What the outcome will be is not known, though there is a possibility of injunction preventing the smelter from operating.

The Coppermine River region, near Coronation gulf, northern Canada, was investigated by an exploring expedition financed by Dr. James Douglas. A large company that could get concession on liberal terms might be successful. A railroad would be necessary if prospecting proves the proper amount of ore. No metallurgical difficulties would

be encountered for the native copper ores. Indications of these were found in diabase and in conglomerate formations. Pieces of native copper 3 by 5 in. are reported.

*Chile.*—A large increase in production took place in 1912. An estimate of copper products is as follows:[1]

| | |
|---|---|
| Blister copper to U. S., pounds | 8,627,421 |
| Copper in ore to U. S., pounds | 27,445,679 |
| Copper to England and France, pounds | 50,136,800 |
| Sundries, estimated, pounds | 220,000 |
| Totals, pounds | 86,429,900 |
| Totals, metric tons | 39,204 |

According to consular reports, the exports in 1910 of bar copper were 17,898 tons, and in 1911, 15,035 tons. Values of exports declared to the United States are reported as follows:

| | 1911. | 1912. |
|---|---|---|
| Bars | $771,105 | $2,129,402 |
| Matte | 563,676 | 1,238,683 |
| Ores | 172,012 | 608,609 |
| Regulus | 488,427 | 897,067 |

In 1875 Chile was the largest producer of copper in the world, the production then being 46,422 tons.[2] A large number of producing mines exist. In 1909 when 78,000 long tons of crude ore, 24 per cent. copper, were exported, the production of ore was 500,000 tons averaging 9.21 per cent. copper. This amount came from 775 mines. The export for the same year was 8,000 tons of 50 per cent. matte and 45,000,000 lb. of blister copper.

The La Grande Mining Co. operating in the Collahuasi district (Tarapaca) produces about 14,000 tons of 20 per cent. ore annually from five mines. In the same district the Poderosa Mining Co. operates five mines on a vein of 4 ft. thickness and 8000 ft. long. In the Poderosa 100,000 tons of 24 per cent. ore are developed. The recent output has been at the rate of 25,000 tons annually.

In the Chuquicamata district, the Chile Exploration Co. is vigorously prospecting a mineralized zone 2 miles in length and up to 1/4 mile in width. Originally the irregular surface ore-bodies, "llamperas," were worked by natives who screen the broken ore. The fines are rich, containing over 11 per cent. copper, and the coarse ore is waste of less than 2 per cent. The method of mining is to be steam-shovel. The treatment of the ore, however, has not been definitely decided on. Wet concentration is not applicable. The copper minerals in the highly acid and decomposed granite are brochantite, $Cu\ So_4\ 3\ Cu.(OH)_2$, 56 per cent. Cu, with atacamite; chalcanthite and small quantities of cuprite, also occur more or less intimately intermingled with the broch-

[1] *Eng. and Min. Journ.*, June 18, 1913.
[2] Juan Blanquier, Copper Mines in Chile, *Min. Sci. Press*, March 29, 1913, p. 480.

antite. A number of small veins of chalcocite have also been encountered, but mostly in depth, and of no immediate importance.

A smelter at Calama now treats probably 20 per cent. of the ores, 80 per cent. being exported via Antofogasta.

The Las Condes district[1] is surrounded by diorite mountains. The ore is high-grade chalcopyrite, about 24 per cent. copper, and shipped at the rate of 6000 tons per year, one-half of which comes from the Disputada mine. The smelter is 15 miles from the mine, and 7000 ft. lower. Transportation is accomplished for $3.00 per ton and mining costs $1.40. Everything is hand work, as in most of the Chilean mines. With machinery much low-grade ore, now a waste product, could be treated. The rich ore occurs in lenses, some of cylindrical shape (150 by 20 ft.).

The Braden Copper Company's mines are connected with the Central Railroad by a 50-mile narrow-gage line and a good wagon road of 34 miles. The "porphyry" is concentrated by water, but the use of the Minerals Separation process was decided upon in 1912. This process is to be in operation when the plant is completed in 1913. The capacity of the mill will be 3000 tons per day. The first flotation unit was started in November, 1912. The work has shown that though a large percentage of oxidized ores is present, an extraction of 70 to 75 per cent. of the copper will be attained. A leaching and a sulphuric acid plant are operated. Tests with the former are being made to treat roasted and oxidized ores. The smelting plant was increased, adding a second blast-furnace, 46 ft. by 180 ft., and a second Pearce-Smith converter. The electric power station, 10,000 kw., at Cachapoal, is completed excepting a fourth unit. The annual capacity of the electrolytic refinery is 35,000,000 lb. of copper. The cost of refined copper will be 7.5 cents per pound.

The development is stated by the report of the consulting engineer, Pope Yeatman, to be as follows:[2]

Developed ore, 16,660,760 tons, average 2.65 per cent. Cu; of this, Teniente No. 1–4,040,834 tons 2.75 per cent. Cu. Probable ore 8,749,444 tons at 2.63 per cent. Cu. Possible ore 18,742,745 tons at 2.61 per cent. Cu. In addition to the last item, possibilities of 15,000,000 tons, chiefly from above Teniente No. 1, may be speculated upon.

*Germany.*—The annual report of the Mansfeld Copper Company, Eisleben, Germany, states that 20,503 metric tons of refined copper were produced in 1912, as compared with 20,850 tons in 1911. In addition in 1911, 3,641,695 oz. of silver were produced, and in 1912,

[1] Juan Blanquier, Copper Mines of Chile, *Min. Sci. Press*, April 19, 1913; p. 583.
[2] End of April, 1913.

3,621,730 oz. of silver. This production was from 879,675 tons of copper schist.

The electric refineries in Germany are the Norddeutsche Raffinerie, the Huttenamt Oker, and C. Wilhelm Kayser & Co. The last concern makes the copper from scrap. The productions in 1911 were 2,545, 2,029 and 1658 metric tons, repectively.

*China.*—Copper is produced on a small scale at the government works at Yalkai, in Kansu. South of Wan Tsang district, in Hupeh, rich copper ores have been discovered. A company has been formed to exploit the deposits.

*Cuba.*—The value of the copper ores, as given in declared invoices from Cuba to the U. S., was as follows: 1911, $620,522 and in 1912, $729,525. The ore to the U. S. amounted to 48,956 long tons, 68,973 tons and 64,566 tons in the years 1910, 1911 and 1912 respectively.

*Japan.*—The 1912 production marks a further considerable advance in Japan's copper industry. According to the estimate of the official mining bureau, the output totaled about 62,000 tons, but reliable private reports put it at 66,000 tons, against 55,000 tons in 1911.[1]

The official statistics give the copper produced in Japan in 1911 as 53,401 tons, and from Formosa in addition, 960 tons.

COPPER PRODUCTION OF PRINCIPAL JAPANESE MINES, 1911 AND 1912.
(In Tons of 2000 lb.)

| Mines. | 1911. | 1912. |
|---|---|---|
| Ashio | 8,483 | 10,530 |
| Kosaka | 6,606 | 8,867 |
| Hitachi | 6,243 | 8,704 |
| Besni | 7,573 | 8,537 |
| Osarusawa and Komaki | 2,172 | 2,385 |
| Ikuno | 1,654 | 1,884 |
| Furokura | 2,014 | 1,719 |
| Ogoya | 1,246 | 1,540 |
| Arakawa | 1,410 | 1,413 |
| Other mines | 20,252 | 23,299 |
| Totals, short tons | 57,653 | 68,878 |
| Totals, metric tons | 52,302 | 62,486 |

The existing copper mines increased their ore output from 10 to 30 per cent. Furthermore, a number of new mines and smelteries have opened in 1912. Among them the Hanaoka mine (production 550 tons) and the Abeshiro mine (production 400 tons) are the most important. Both are situated in the north. The exports were divided chiefly between England, China, United States and France. Japan's copper export in 1912 amounted to 38,370 tons, while the home consumption absorbed 27,630 tons, or 11,000 tons more than in the preceding year. The copper output of Nagasaki, Japan, in 1911 was reported as 5,048,968 , valued at $602,954.[2] The principal copper mines in this district

[1] *Mehr. des Mines*, March 31, 1913.
[2] *Dig. Consr. and Trd. Rpt.*, Oct. 14, 1912.

are the Ota mines in Yamaguchi Prefecture, on the main island of Japan, producing about 1,000,000 lb. annually; the Makimine mines in Miyazaki Prefecture, producing over 1,000,000 lb. annually; and the Hibira mines, also in Miyazaki Prefecture, producing about 2,000,000 lb. annually.

*Mexico.*—As in 1911, in spite of the disturbed conditions, a fair showing was made in the copper production. Most of the output is from Sonora and Baja California, although smaller producers were working in San Louis Potosi and other states. More than half the copper produced in Mexico is exported to the United States. The approximate values of copper exports to the United States in 1911 were $11,500,000 through Aguascalientes, $890,000 from Durango, $1,500,000 from Vera Cruz; $1,760,000 through San Louis Potosi; the total value being $22,800,000. In 1912 the U. S. received 93,039 long tons of ore, valued $2,118,785 and 124,742,193 lbs. of copper in bars, etc., valued $18,119,079.

In San Luis Potosi the smelter at Metehuala, a copper producer, handled 550 tons of ore per day, mostly from the Dolores and the Cobriza mines. The copper property, Tiro General, was taken over by Americans in 1912.

The Greene Consolidated Copper Co. in Sonora is a large producer. In 1912 returns to the stockholders, after the expenditure of $4,000,000 for rebuilding the mill and erecting the smelter, were satisfactory. The production of the Greene properties was 48,157,847 lb. at a cost of 10.31 cents. The net earnings of the year were $2,580,749. In 1911 the production was about as in 1910 and 1909, viz., 44,897,466 lb. Costs in these years were 9.84 cents in 1911, 11.51 cents in 1910, and 11.64 cents in 1909. In 1912, 895,406 tons of ore recovering 2.252 per cent. copper, 1.07 oz. silver and 0.005 oz. gold, were treated from Mexican properties of the Greene-Cananea, the controlling company. The average grade of all ore treated was 2.82 per cent. copper and 1 1/2 oz. silver.

In addition to facts given[1] in regard to the 1911 production of the Greene Consolidated, the following figures are of interest. The face of the combination adit passed beyond the Eliza zone and at the beginning of 1912 was 5200 ft. from the portal, and had entered the Cananea claim.

Two hundred tons per day of smelting ore is expected from the flanks (porphyry contacts), of the Puertecitos hill. Irregular ore from the Capote and Eureka faults, which showed large masses of gossan along the surface, has been developed; bodies of pyrite encountered in the limestone are paying as long as they contain over 2 1/2 per cent. copper. To avoid the tendency toward low-grade matte, a 4/5 interest in the

[1] Vol. XX, MINERAL INDUSTRY, p. 206.

Superior Bonanza mine (Imuris, Sonora), which furnishes siliceous ore, has been purchased.

The Cananea Consolidated Copper Company, controlled by the Greene Consolidated, owns and operates the following mines; the character of ore deposits and formation are given:[1]

| Mine. | Predominant Formations. | Ore. |
|---|---|---|
| Cananea-Duluth | Siliceous brecciated diorite | Chalcopyrite and tetrahedrite. |
| Cobre Grande | Decomposed diorite in veins in siliceous diorite. | Malachite, chalcocite and chalcopyrite. |
| Kirk No. 9 | Soft decomposed limestone | Chalcopyrite and bornite. |
| Kirk No. 15 | Diorite | Chalcocite and cupriferous pyrite. |
| Veta Grande | Diorite | Chalcocite and cupriferous pyrite. |
| Oversight | Soft decomposed diorite | Chalcocite and cupriferous pyrite. |
| Capote | Brecciated quartzite and diorite | Chalcopyrite and bornite. |
| Eureka | Limestone | Chalcopyrite and cupriferous pyrite. |
| Elisa | Metamorphosed limestone garnet rock. | Chalcopyrite. |
| Henrietta | Siliceous diorite and quarts porphyry. | Chalcopyrite and bornite. |
| Puertecitos | Metamorphosed limestone and granodiorite. | Malachite, bornite and chalcopyrite. |

In 1911 more than half the ore came from the Oversight. Costs per ton were lowest in this mine, being $1.47, and ranged to $9.91 per ton in the Puertecitos, the average being $2.46, as compared with $2.93 per ton in 1912. At the beginning of 1913 the rate of production was 9,000,000 lb. of copper per month.

The smelter of the Democrata Mining Company at Cananea had its new 250-ton furnace in operation toward the end of the year 1912, and produced at the rate of 600,000 lb. of copper per month.

The smelter of the Minneapolis Copper Co. at Cumpas is to be blown in early in 1913. The product will then go to refineries directly instead of to the Copper Queen Smeltery at Douglas, Arizona.

The Boleo Copper Company treated a large tonnage of oxidized ore of a somewhat lower grade than in the fiscal year ending in 1911. One-half approximately of the copper product goes to England and one-half to France.

The railroad transported 652,312 metric tons of ore, as compared with 605,661 tons in 1911. The ore smelted was 261,000 tons in 1905; 304,000 tons in 1906; 319,000 tons in 1907; 340,000 tons in 1908; 330,000 tons in 1909; 365,000 tons in 1910; 355,100 tons in 1911 and 364,000 tons in 1912.

The copper yield was 3.51 per cent. in 1912 as compared with 3.97 in 1905. The copper produced was 12,650 tons in 1912, 12,360 in 1911 and 13,040 tons in 1910. Dividends were increased by 50 per cent. over 1911.

[1] *Eng. and Min. Journ.*

*Norway.*—The old Aamdals mine in Telemarken district in southern Norway, that periodically has been worked for about 300 years, was taken up again under the name of the Bandak Elektrolytiske Kobberverk, A/S. The ore consists of pure copper pyrites, and was previously concentrated and exported as a concentrate of about 25 per cent. Cu. The present work is based on a process patented by Mr. Hybinette, by which the raw ore of about 2 per cent. is being crushed, roasted and leached, whereupon the solution is treated electrolytically. Sufficient water power is developed near the mines.

Experiments with copper pyrites from the Orkla and Sulitjelma mines, in which much foreign capital is invested, have been equally successful, and the ores may be treated by the Hybinette process. They were formerly shipped to Germany and Sweden. At the Sulitjelma the Knudsden process is satisfactory. In 1912, 149,600 tons of ore were produced, of which 123,250 tons were exported, 14,850 smelted and 11,500 treated by Elmore process. From 14,400 tons of smelted ore and 5750 tons from the Elmore process, 1024 tons of Bessemer copper resulted. The presence of ore-bodies in the hanging was established. The Roros copper mines produced 587 tons copper and 11,000 tons of export ore. The Birtevarre copper mines in Lyngen produced 282 tons Bessemer copper.

*Peru.*—The production[1] in 1912 was estimated as follows:

| | |
|---|---|
| Blister copper to U. S. | 43,891,439 lb. |
| Copper in ore to U. S. | 11,373,009 lb. |
| Copper to England and France | 2,900,000 lb. |
| Sundry | 220,000 lb. |
| Total | 58,384,448 lb. |
| Metric tons | 26,483 |

Mr. E. E. Marshall estimates 27,400 long tons for 1912. The entire output of Peru is exported. The Cerro de Pasco Mining Co. had the largest production in its history. This company began the installation of a hydroelectric plant near Oroya, to develop 10,000 h.p., costing about $2,000,000. Five blast-furnaces were remodeled and a new converter plant was completed. A 15-mile railroad to the company's coal mines at Quisguarcancha was constructed.

The output of the Morococha mines goes to the Cerro de Pasco. According to figures of the Central Railroad of Peru 500 to 600 tons of 8 to 15 per cent. Cu. ore, averaging 10 to 40 oz. silver, are shipped daily. The pumping plant for the Natividad is expected to operate in 1913. Preparations to operate San Miguel mine by open cut are under way. The adit, 4000 ft. long, will cut the S. Francisco vein 400 ft. below the lowest workings. Two years will complete the tunnel, which is at the

[1] *Eng. and Min. Journ.*, June 18, 1913.

level of lowest workings of the Natividad and which will serve for draining.

The Backus & Johnson Co. reports that during the year 83,789 tons of ore were smelted and 8790 tons of high-grade matte were produced, with a net value of $2,493,440, while in 1911 only 64,546 tons were treated. $350,000 was spent on new plant in 1912, of which the principal addition was a hydroelectric power plant that will give the company a total of 3000 to 4000 h.p. at Casapalco. The smelting capacity is now 800,000 lb. of matte per month. The directors decided to erect basic-lined converters.

The Anglo-French Ticapampa Co. has been mining for nearly 40 years, near Recuay, shipping high-grade lead silver ore and lixiviating low-grade products. The copper products are expected to increase; 149 tons of ore and 15 tons of matte were shipped in 1912.

The Rio Blanca smelter was purchased by E. E. Marshall, and may be started in 1913.

*Russia* (By J. P. Hutchins).—The total copper production for 1912 is estimated at about 35,000 tons. The respective productions for the first 6 months were as follows: Ural region, 9180 tons; Causasus, 4777; Siberia and Kirghiz steppes, 2126; by-product from chemical works, 598; total, 16,681 tons. The production for the first 8 months of 1912 was 22,300 tons.

These figures show that the principal copper region of the Russian Empire is the Ural—the Caucasus may be considered merely as the southern extension of the Urals. This is a region of old rocks, granites, limestones and crystalline schists. The principal mines are in sulphide bodies generally containing less than 5 per cent. copper, but well adapted to pyritic smelting. Generally favorable conditions for mining obtain, such as cheap labor, good transport, plentiful timber and water, accessible fluxes, inexpensive coke. The protective tariff, of about 7 cents per pound, results in the price of copper being about 25 to 33 1/3 per cent. higher than in London or New York. Foreign capital is largely interested in copper mining in the Russian Empire and the general success of these operations has stimulated an active search for new copper mines.

The Ural and Siberian steppe coppers had a good year. The Caucasus copper region is making progress toward eventual success. Here there are large low-grade pyritic deposits, but metallurgical difficulties, due to a considerable siliceous content, which hinders cheap smelting,

serious hindrance. However, in the last year it appears that

rgical developments were made that this business will

ong career of difficulty.

It is thought that Russia will eventually become an exporter of copper and, later, when progress shall result in an increased demand, it will again be imported. There is, undoubtedly, an immense future market for copper in the Russian Empire.

The largest works of the Ural are the Bogoslowski (1909, 3917 tons = 239.140 pood) and the works at Nischny Tagilsk, belonging to the Demidow heirs (in 1909, 1125 t. = 68,700 pood); besides that the works of the Kyshtym Co. are producing more copper every year.

The Caucasus Co. operating low-grade property at Dzansul, according to the report covering the year to May 31 (Russian), 1912, shows 3030 tons copper produced, bringing £256,195; the cost was £166,019 not including interest. The plant treats 500 tons ore daily. An additional 250-ton unit will be in operation in 1913 and the order is given for another unit. The overburden, from 10 to 100 ft. thick, is now removed by hydraulicking; and the ore is mined by mill-holing. A new reverberatory is built 89 by 19 ft. The ore reserves a year ago were 3,600,000 tons.

PRODUCTION OF COPPER IN RUSSIA.
(In poods. 1 pood = 16.381 kg. = 36.114 lb.)

| Years. | Ural. | Caucasus. | Siberia. | Kirghiz Steppe. | Altai. | Finland. | Various. | Total. |
|---|---|---|---|---|---|---|---|---|
| 1896 | 167,574 | 149,698 | ..... | 1,868 | 13,239 | 23,640 | ..... | 356,019 |
| 1897 | 220,783 | 162,534 | ..... | 3,586 | 15,427 | 21,360 | ..... | 423,690 |
| 1898 | 236,863 | 173,993 | ..... | 2,440 | 16,341 | 15,445 | ..... | 445,082 |
| 1899 | 253,610 | 171,568 | ..... | 5,754 | 15,292 | 13,664 | ..... | 459,888 |
| 1900 | 241,148 | 227,079 | ..... | 11,273 | 11,322 | 13,354 | ..... | 504,176 |
| 1901 | 217,063 | 247,348 | ..... | 21,993 | 13,193 | 17,311 | ..... | 516,908 |
| 1902 | 279,135 | 213,273 | ..... | 25,238 | 7,431 | 13,231 | ..... | 538,308 |
| 1903 | 265,116 | 262,919 | ..... | 17,902 | 7,546 | 10,126 | ..... | 563,609 |
| 1904 | 265,915 | 296,666 | ..... | 30,513 | 7,344 | ..... | ..... | 600,438 |
| 1905 | 225,800 | 223,800 | 67,000 | ..... | ..... | ..... | 53,900 | 570,500 |
| 1906 | 288,600 | 232,300 | 40,500 | ..... | ..... | ..... | 74,700 | 636,100 |
| 1907 | 457,904 | 310,244 | 68,957 | ..... | ..... | ..... | 65,253 | 902,358 |
| 1908 | 522,584 | 296,379 | 155,116 | ..... | ..... | ..... | 54,616 | 1,028,695 |
| 1909 | 530,778 | 391,200 | 150,582 | ..... | 2,940 | ..... | 57,984 | 1,126,584 |
| 1910 | 565,957 | 470,970 | 196,019 | ..... | 3,480 | ..... | 57,017 | 1,293,443 |
| 1911 | 808,982 | 486,964 | 228,007 | ..... | 1,709 | ..... | 55,979 | 1,581,641 |

*Servia.*—The blister copper exported during 1911 is reported as 6827 tons, valued at $1,849,812.

Of the smelting works only the copper-smelting establishment of a French company, which also owns the copper mine at Bor, in eastern Servia, is worth mentioning.

The works have four blast-furnaces. During the fiscal year 1911–12 their production was 7575 metric tons of merchantable copper, which was an increase of 1771 tons over the production of the previous year. During the latter half of 1912 the Servian mobilization took away nearly all of the employees and the operations are now on a very reduced scale.

*Spain.*—The official figures of copper-ore production for 1911 are 3,284,184 metric tons valued 35,654,223 pesetas at the mine. The number of mines working was 87. The ore smelted in Spain was 1,755,750 tons, producing 18,295 tons of blister copper valued $4,939,650 and 12,353 tons of copper shells valued $2,461,225.

The exports of copper products from Huelva, Spain, were as follows:[1] Copper ingots, 19,463 short tons, in 1911, and 24,472 short tons in 1912; copper pyrites 1,152,486 short tons in 1911, 1,047,417 short tons in 1912; precipitate of copper, 13,790 short tons, 1911, and 13,320 short tons in 1912.

The Rio Tinto Co. is the largest producer.

OUTPUT OF RIO TINTO MINES.
(In Long Tons.)

| Year. | Pyrites for Shipment. | Ores for Local Treatment. | Total Mined. | Average Copper Contents. | Copper Produced at Mines. | Pyrites Sold. | Washed and Other Sulphur Ores Sold. |
|---|---|---|---|---|---|---|---|
| 1901 | 633,949 | 1,294,827 | 1,928,776 | 2.627% | 21,100 | 641,935 | ..... |
| 1902 | 627,967 | 1,237,322 | 1,865,289 | 2.517% | 21,659 | 595,092 | ..... |
| 1903 | 688,919 | 1,229,619 | 1,918,538 | 2.390% | 21,565 | 667,748 | 118,174 |
| 1904 | 672,344 | 1,276,475 | 1,948,819 | 2.340% | 21,218 | 663,744 | 157,810 |
| 1905 | 627,336 | 1,202,768 | 1,830,104 | 2.363% | 19,530 | 660,724 | 308,184 |
| 1906 | 655,328 | 1,268,388 | 1,923,716 | 2.411% | 21,287 | 632,307 | 477,843 |
| 1907 | 641,858 | 1,265,090 | 1,906,948 | 2.417% | 21,251 | 607,944 | 619,814 |
| 1908 | 604,275 | 1,115,610 | 1,719,885 | 2.265% | 24,256 | 589,815 | 668,477 |
| 1909 | 604,799 | 1,184,188 | 1,788,987 | 2.349% | 24,364 | 600,946 | 569,604 |
| 1910 | 637,020 | 1,509,945 | 2,146,765 | 2.097% | 22,790 | 578,443 | 683,605 |
| 1911 | 649,215 | 1,536,390 | 2,185,605 | 2.144% | 21,880 | 662,259 | 841,964 |
| 1912 | 698,399 | 1,708,573 | 2,406,969 | 2.180% | 25,623 | 668,861 | 977,812 |

The total quantity of copper sent to market in 1912, as refined and standard copper, or as copper in pyrites, was 39,925 tons. The market price of standard was much better than in the previous year, the average price being £73 1s. 3d. per ton, against £56 1s. 9d. in the previous year.

The report for the calendar year 1912 says: "The preparation of the lodes for the later removal of minerals has been continued. Machine drilling, both in open-casts and underground operations, continues to give satisfaction, and the steam shovels are working as usual. The company's railway and pier handled the shipments promptly, though they were larger than in previous years. . . . All the reservoirs, which were full in the early part of the year, have been heavily drawn upon, and will require careful nursing. . . . . Affairs at the mines are in sound condition, and the demand for pyrites and sulphur ore continues to increase, and the future outlook in regard to the price of copper is not unsatisfactory.

*United Kingdom.*—In 1911 the production of copper ore was 3135 long tons, the precipitate 127 tons and the fine copper 392 tons. In

[1] *Bly. Conslr. and Trd. Rpts.*, July 2, 1913.

1912 the exports of ingots was 12,788 tons, of brass 10,933 tons and sulphate 84,146 tons. The imports were 98,226 tons of ore, 51,565 tons of regulus and precipitate and 94,975 tons of unwrought copper. The ore comes largely from Chile, the regulus from Spain, Mexico and South Africa, and the copper from the United States and Australia. A list of the copper refineries and smelters is found in *Eng. Min. and Journ.*, February 1, 1913.

Copper and copper precipitate comes principally from Glasdir mine in Merioneth. Copper precipitate is obtained from mine water on Parys Mountain in Anglesey. Cornwall produced large quantities formerly, but is no longer the main supply. In 1863, 210,000 tons were produced, valued at more than £1,000,000.

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## METALLURGY OF COPPER IN 1912

BY L. S. AUSTIN

*Progress in* 1912.—We may note that the Cananea practice of ore-bedding has been extended to roasting ores. The system, both for crude and for sulphide ores, is a complete one, including cheap methods of sampling, bedding and reclaiming. Another system, now in use for lead-bearing ores at the International plant, Tooele, Utah, and at Tacoma for copper ores, appears to have an advantage in that the items of a varied charge may be drawn off into a charge-car.

Utley Wedge discusses the question of sulphatizing roasting with particular reference to its performance in the Wedge roasting furnace. He shows that it is possible, by the addition of sufficient pyrite, to roast until 95.2 per cent. of the copper is in soluble form. Other experiments made by him were not so successful.

The sintering of ores, both by pot-roasting, and particularly with

the Dwight-Lloyd machine, is increasingly practised. The latter machine has been introduced into other countries from its original home in the United States. The writer is particularly impressed by the fact that improved machines and methods rapidly spread into the practice of copper metallurgy throughout the world. New plants are generally more extensive, more thoroughly built, and consequently more costly than ever before. Incident to the separation of ores into coarse and fine, and the sintering of the latter, the daily tonnage of the blast-furnace has been doubled, while at the same time slags are as clean. Another advantage of this increased tonnage is that the smelting zone of the furnace and the settler are better kept open and hot, and so longer campaigns result.

Increased attention is being given to the recovery of flue-dust by settling-chambers, bag-houses or by gas-washers. In the case of concentrates, which are high-grade, and consisting of fine material, even though the fine is sintered, the recovery of the dust cannot be neglected. With low-grade copper ores the question is not the same, and, when much of the ore is coarse, it may pay to neglect an attempt at recovery.

E. P. Mathewson has presented before the Eighth International Congress of Applied Chemistry a valuable paper on the reverberatory furnace, including a discussion of the underlying principles and many details relating to performances and dimensions. S. S. Sorensoon shows that it is possible to push an oil-fired reverberatory to an output of 666 tons daily. The regenerative reverberatory furnace is coming to the front again.

According to the Pierce-Smith Convertor Co. some 80 per cent. of the copper produced in the United States is being converted in the Pierce-Smith type of converters, or on basic lining under license from them in the old formerly acid-lined shells.

We discuss quite fully[1] the properties of copper and its alloys. We know that high-conductivity copper must be as pure as possible, but for many uses in the arts moderate amounts of antimony and especially of arsenic are unobjectionable. The constitution of the copper alloys is now better understood and their heat-treatment, as in the case of steel, is more emphasized.

## Ores and Ore Handling

*Arsenic and Sulphur in Butte Ores.*[2]—Arsenic is chiefly due to the presence of enargite. At the Washoe Works, Anaconda, from 3.3 to

[1] Under the head of "Smelteries" will be found details of practice which will particularly appeal to the smelter man.

[2] Paper 70, *U. S. Geol. Surv. Report*, p. 70.

5.5 per cent. of the metal is recovered from about 22,000 lb. of flue-dust, the finest portion of the 60 to 80 tons collected daily. Thus there is obtained 11 to 18 tons of arsenic monthly.

In 1905 the Washoe plant, treating 7000 tons of ore daily, produced 42,200 lb. (693,000 cu. ft.) of gases per minute, containing 1.5 per cent. sulphur; or 3 per cent. of $SO_2$ or 1.37 per cent. S per volume. This is equivalent to 49.4 tons of sulphur in 24 hours. Over half of this comes from the roasting furnaces.

*Ore-bedding and Blast-furnace Charging at Cananea.*[1]—Particulars of this practice are given in MINERAL INDUSTRY, XVI, 344, XVIII, 191, XIX, 189. From the article of Morris J. Elsing we get further details as follows:

*Roaster Bedding Plant.*—A system has been installed by the Stephens-Adamson Mfg. Co. for handling the concentrate. This is emptied into receiving-bins from railroad cars that come from the mill. From the bottom of the bins through a steel chute provided with an ore-gate it is fed upon a conveying-belt. In order to assure the steady feeding of the wet material an attendant is stationed at the chute with a compressed-air barring device. This consists of a piece of 1-in. pipe 6 ft. long, terminating in a tapered pipe with a 1/4-in. opening; the other

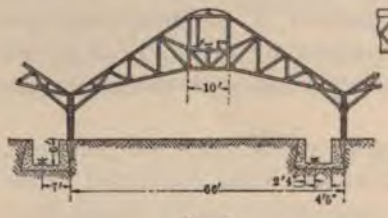


FIG. 1.

FIG. 2.

end connects by hose to a source of compressed air. The compressed air thus applied is effective in loosening the material which would otherwise hang up. The concentrate is bedded in the same way as is the blast-furnace charge. The reclamation of the bedded concentrate is accomplished by means of a transverse belt-conveyor mounted on a movable carriage. The roaster charge, shoveled upon this belt, discharges to a longitudinal one, delivering to the roaster bins. A uniform charge for roasting and for reverberatory treatment is thus obtained. Fig. 1 is a section and Fig. 2 a side elevation of the ore-bedding plant. Conveyor No. 7 is a 20-in. belt which takes the ore to the blast-furnaces.

The bedded charge is delivered into narrow steel storage-bins of 75 tons capacity above each blast-furnace. These bins feed steel

[1] *Min. and Sci Press*, CIV, 619.

pockets of one ton capacity each, which are partly emptied into the furnace, and partly on the feed-plate through a chute and deflecting gate.. Coke is brought from the stock-pile to the furnace in wheelbarrows.

Under the system of bedding here used it is possible to have an exact knowledge of the composition and physical character of the charge, and because of this it is possible to increase the speed of smelting, to reduce excessive accretions in the furnace, to more closely save fluxes, coke and air-blast, and to increase the porportion of fine material on the charge. In the mild, dry climate of Northern Mexico this open-air bedding system operates under the most favorable conditions.

*Metals in the Ores and Smelter Products of the Butte District, Mont.*[1]—W. H. Weed gives the loss in calcining matte as follows: Cu, 1.0 per cent.; Pb, 1.8 per cent.; Bi, 1.6 per cent.; Sb, 8.15 per cent.; As, 27.16 per cent. and Te and Se, 2.8 per cent. The further loss in smelting he gives thus: Loss as flue-dust by smelting the calcined matte: Cu, 1.0 per cent.; Pb, 0.13; Bi, 2.08; Sb, 1.27; As, 2.09; and Bi and Te together, 2.7 per cent. The loss in the slag: Cu, 1.0 per cent.; Pb, 7.58; Bi, 1.06; Sb, 5.02; As, 1.74 per cent; and Te and Se none.

Based upon ores mined in 1897, their average composition is: Cu, 6.0 per cent.; Bi, 0.004; Sb, 0.02; Se and Te, 0.001 per cent.; with Ag, 6.0 oz. and Au, 0.03 oz. per ton. The matte resulting from these ores, contained Cu, 60.0 per cent.; Bi, 0.04; Sb, 0.1; Se and Te, 0.01 per cent.; with Ag 60 and Au 0.3 oz. per ton. The ores now worked do not yield as high values in silver and gold. The percentage values of metals in three lots of matte produced from the Butte smelteries in 1897, and shipped east for further treatment are given in the subjoined table:

| Metal. | 1. | 2. | 3. | Metal. | 1. | 2. | 3. |
|---|---|---|---|---|---|---|---|
| Cu | 60.76 | 49.34 | 61.42 | Bi | 0.042 | 0.0337 | 0.0049 |
| S | 23.25 | ..... | ..... | Sb | 0.079 | 0.1010 | 0.133 |
| Fe | 11.43 | ..... | ..... | As | 0.045 | 0.0484 | 0.128 |
| $Fe_2O_3$ | 1.13 | ..... | ..... | Se and Te | 0.015 | 0.0021 | 0.0042 |
| Zn | 2.41 | ..... | ..... | Mn | trace | ..... | ..... |
| Pb | 0.59 | 0.0738 | 0.037 | Ag (oz. per ton) | 61.200 | 14.6 | 18.2 |
| Ni | 0.001 | ..... | ..... | Au (oz. per ton) | 0.290 | 0.05 | 0.05 |

The mattes now produced are much lower in copper, 40 per cent. being usual and as low as 30 per cent. being made.

## Roasting and Sintering

*Sulphatizing Roasting of Copper Ores.*[2]—For the treatment of copper-bearing ores of tenor, too low to pay by smelting, Utley Wedge proposes

[1] *Report* No. 74, *U. S. Geol. Surv.*, p. 7.
[2] *Eighth Int. Cong. Appl. Chem.*, III, 151.

a sulphatizing roast of the ore with subsequent leaching to extract the copper in soluble form.

Where the ore contains insufficient sulphur, this should be added generally as pyrite or chalcopyrite. Theoretically, one part of copper needs one-half part of sulphur, but practically an excess must be present. When copper is present as a sulphide (CuS) we have first its decomposition below 350° C. Thus: (1) $2CuS = Cu_2S + S$. Above 350° the sulphur burns to $SO_2$, and $Cu_2S$ decomposes. (2) $2Cu_2S + 5O_2 = 2CuO + 2CuSO_4$. Above 500° C. the principal reaction is (3) $Cu_2S + 2O_2 = 2CuO + SO_2$.

Thus, the tendency is for a portion of the copper sulphide to become oxidized to CuO, and in roasting the endeavor is to prevent this oxidation, and obtain as much $CuSO_3$ as possible. The presence of iron sulphide assists in sulphatizing the copper oxide. At temperatures below 600° C. some basic iron sulphate forms, which above 530° C. roasts to $Fe_2O_3$, and $SO_3$, and this $SO_3$ gas may combine with the CuO to form $CuSO_4$, which is stable below temperatures up to 650° C.; or the CuO may react directly with the $Fe_2(SO_4)_3$ thus: (4) $3CuO + Fe_2(SO_4)_3 = Fe_2O_3 + 3CuSO_4$.

The $Fe_2O_3$, formed from the iron sulphide, also reacts on the $SO_2$ to form $SO_3$ at temperatures between 500° C. and 750° C., and the $SO_3$ thus formed tends to combine with the CuO to form $CuSO_4$.

A test (No. 621) made upon straight ore in a Wedge mechanical furnace was as follows:

The ore contained Cu, 1.07 per cent.; Fe, 49.25; S, 32.6; $SiO_2$, 6.8; and 2.18; $Al_2O_3$, 1.59 per cent.; the copper being present as chalcopyrite, Mg, the iron as pyrite and pyrrhotite. A sample of the ore, when calcined, gave of water-soluble copper ($CuSO_4$) 0.35 per cent. or 27.8 per cent. extraction; of acid-soluble copper (CuO), 0.8 per cent. or 63.4 per cent. extraction, leaving of insoluble copper 0.11 per cent. The total extraction was 1.26 out of 1.38 per cent. contained in the roasted ore, or 91.2 per cent. This calcine was re-roasted, then leached with results as follows: Water-soluble copper, 0.76 per cent. or 60.3 per cent. extraction; acid-soluble copper, 0.48 or 38.1 per cent. extraction, leaving 0.02 per cent. insoluble. The total extraction was therefore 98.4 per cent.

Test (No. 620) was made upon ore containing chalcopyrite with a schistose gangue of the composition Cu, 3.52 per cent.; Fe, 9.76; S, 9.54, and insol., 66.5 per cent. This was roasted in a Wedge furnace 9 ft. 9 in. diameter, having five hearths, four fired with coal. Analyses made as the roasting was completing showed: water-soluble copper, 60 to 70 per cent.; acid-soluble copper, 20 to 22 per cent., or a united

extraction of from 80 to 92 per cent. The $SO_2$ and $SO_3$, generated in the upper hearth, was drawn downward over the ore of the lower hearths.

Test (No. 125) was made upon an ore containing copper as bornite with some copper silicate and carbonate, and yielding by analysis Cu, 3.4 per cent.; Fe, 11.05; S, 13.02; $SiO_2$, 63.9 per cent. The ore was ground to 20-mesh and given a single treatment in a small furnace. The calcine yielded: water-soluble copper 80.8 per cent. and acid-soluble copper 11.8 per cent. of the total copper contents, a total recovery of 92.6 per cent. These results have been duplicated in a large Wedge furnace of 20 ft. diameter.

Test (sample No. 7) was made on a copper-nickel ore containing Cu, 1.85 per cent.; Ni. 2.75; Fe, 47.78; S, 30.85, and $SiO_2$, 15.3 per cent. It was desired to extract the copper and to leave the nickel in the ore after leaching. Extraction was as follows:

| | Copper. | Nickel. |
|---|---|---|
| Water-soluble | 69.2 per cent. | 13.6 per cent. |
| Acid-soluble | 12.8 per cent. | 4.4 per cent. |
| Total soluble | 82.0 per cent. | 18.0 per cent. |

while there was left in the ore 0.29 per cent. copper and 2.8 per cent. nickel.

Ores containing little or no sulphur can be treated to a sulphatizing roast upon addition of pyrite, thus:

Test (No. 604) contained copper as carbonate, this gangue being porphoritic, and contained Cu, 3.14 per cent.; Fe, 2.25; S, none; and insol.; 85.5 per cent. For roasting it was mixed with 5 per cent. of pyrites containing 47.5 per cent. Fe. The ore was calcined in a five-hearth Wedge mechanical roaster and showed a total extraction of 92 per cent. The solution resulting from the leaching was pure, containing 0.1 to 0.2 per cent. $Fe_2O_3$ but had 7.0 per cent. copper sulphate. Copper, thrown down from this solution with pure scrap iron, gave a 96 per cent. precipitate.

A similar test, adding pyrites, showed the following extractions: Ore on leaving hearth No. 1, 79.3 per cent. of copper soluble in water, on leaving hearth No. 2, 81.4 per cent.; after hearth No. 3, 93.4 per cent.; after hearth No. 4, 95.2 per cent., and after hearth No. 5, 95.2 per cent. soluble. The calcine leached readily with cold water using a ton of water per ton of ore. The solution was used successively on other batches of ore until it was brought to the strength of 15 per cent. $CuSO_4$ while

containing but 0.1 per cent. Fe. The tailing retained but 0.08 per cent. Cu.

*The McMurty-Rogers Pot-roasting Process.*[1]—Besides particulars already given[2] we present the following: The process is used principally on fine concentrate; the charge must contain 15 to 35 per cent. $SiO_2$ and 15 to 25 per cent. sulphur. The pots are 8 ft. 6 in. diameter, when used for ore, and 4 ft. 6 in. deep with vertical sides. A grate, 10 in. above the bottom, is pierced with 5/8-in. holes. About 1000 cu. ft. of air is supplied per minute at 13 to 20 oz. pressure per square inch. The pot will hold 8 to 10 tons, and a charge is completed in 8 to 10 hours. On ore charges 6 to 9 per cent. water is used, and on rich mattes 3 to 4 per cent. Some 400 to 500 tons are treated weekly at a cost of 78 cents per ton.

## Furnace Reactions and Products

*Chemical Reactions in Reduction Processes.*[3]—Frederick Laist summarizes the igneous reactions at Anaconda, most of which have been presented in text-books of the metallurgy of copper, and in former numbers of the Mineral Industry. We draw attention to novel points:

In the roasting furnace 90 per cent. of the charge is concentrate, and the remaining 10 per cent. is made up of fine ore and limestone. The limestone is not decomposed into CaO and $CO_2$ at the roasting temperature. All the arsenic present in the ore is driven out, but unites with the copper to form arsenate and arsenite of copper. When the ore reaches the reverberatory these compounds are decomposed, a portion going into the slag, the remainder into the matte.

In the reverberatory furnace the limestone decomposes, and with iron oxide and silica, forms 86 per cent. of the slag; the remaining 14 per cent. being one-half $Al_2O_3$ and the remainder MgO, MnO, Cu, S, and the alkalies. The aim is to keep the slag silicious to prevent its corroding the acid (silica-brick) lining.

In the upper part of the blast-furnace, decomposition goes on by which $FeS_2$ is broken up into FeS and S, the sulphur leaving as such, as is shown by the yellow-fume produced on the addition of a fresh charge. Limestone is decomposed in this place into CaO and $CO_2$.

At the basic-lined converter it is important that the slag shall be poured while 1.5 per cent. of the iron is still unoxidized. Otherwise foaming may occur. This may be due to the formation of copper sili-

ich tends to thicken the slag. It has been suggested that foam-

[1] elting," D. M. Levy.
[2] DUSTRY, XVI, 219, XVIII, 221; *Trans. I. M. M.*, XVI, 311.
[3] *ong. Appl. Chem.*, III, 97.

ng may be due to the rapid evolution of sulphur at this time, as has been proved by samples taken at 10-minute intervals.

*Alumina in Copper Slags.*[1]—H. C. Bellinger comments on the behavior of alumina in slags, showing that the element sometimes acts as an acid, but more frequently as a base. He shows that one metallurgist, assuming that alumina in combination with silica would act as a base, the remainder as an acid, was able to make a practicable slag. From diversified experience the author of the paper concluded that we must look beyond mere chemical analysis to evolve a reasonable principle of procedure. Some engineers for instance have found under certain conditions, that by calculating the alumina soluble in acids as acting as an acid, and the insoluble alumina as a base or as a neutral magma, they have obtained satisfactory results.

James Buchanan and F. E. Lee advance another working hypothesis:[2] They assume that the CaO present combines with $Al_2O_3$ to form a lime alumina silicate, $Al_2O_3$, 3CaO; $6SiO_2$, the oxygen in the alumina equalling that in the lime, while the rest of the alumina acts as an acid. Take a slag containing $SiO_2$, 44 per cent.; $Al_2O_3$, 17.4; CaO, 19.2; FeO, 16.1, and MgO, 2.5 per cent. The oxygen in the 17.4 per cent. $Al_2O_3$ would be 8.17 per cent., while in the 19.2 per cent. of CaO would be 5.49 per cent. oxygen. Subtracting we have 2.68 per cent. of $Al_2O_3$ which would be added to the 23.47 per cent. of oxygen in the $SiO_2$. Uniting the oxygen in the bases, viz., CaO, 5.49; $Al_2O_3$, 5.49; FeO, 3.57; and Mg, 1 per cent. or a total of 15.55 per cent., we compare it with the acid oxygen 23.47 and find the ratio 1 to 1.68, a good economic slag. They have worked out the rule as the result of this experience at the smelting works of the Consol. Mining and Smelting Co. of Canada, Ltd., at Trail, B. C.

Frederick Laist[3] thinks that with a high silica the alumina acts as a base, and that in a slag high in bases, the alumina acts as an acid; and that a slag behaves according to its needs.

*Constitution of Copper Slags.*[4]—Charles H. Fulton discusses the constitution of these slags from the standpoint of the mineralogist, considering them as a mixture of two minerals. One is the ortho-silicate (singulosilicate) of the composition $R_2SiO_4$ having the silicate degree, or ratio of oxygen in the base to the oxygen in the silica, as 1 to 1. The other mineral is the meta-silicate (bisilicate), having the silicate degree 1 to 2. A series is formed in which the two minerals are the end-members, and all the compositions between are various mixtures of the two minerals. The slags ordinarily made in copper smelting may be:

[1] *Trans. A. I. M. E.*, June, 1912; *Min. Mag.*, VII, 143; MINERAL INDUSTRY, XVIII, 233; *Eng. and Min. Journ.*, LXXXVI, 270, 483.
[2] *Min. and Eng. Rev.*, Feb. 15, 1913.
[3] *Eighth Int. Cong. Appl. Chem.*, III, 97.
[4] *Bull. A. I. M. E.*, Dec. 1912; Principles of Metallurgy, Fulton.

| | CaO | FeO | $Al_2O_3$ |
|---|---|---|---|
| (1) Mellinite and augite | high | low | high |
| (2) Augite and iron-lime olivine | lower | higher | high |
| (3) Augite and high-iron olivine | low | high | lower |
| (4) Hypersthene and high-iron olivine | low | high | low |

In the series we have lime and alumina dropping, while the iron rises. If the composition of the slag is such that neither of these minerals can form, and alumina is high, it is apt to crystallize out as spinel, causing furnace difficulties. The formation of spinel is greatly aided by the presence of magnesia or zinc, even when in small quantities.

Ordinarily MgO passes to the hypersthene, zinc to the high-iron olivine. If a slag is to carry much alumina, it must also have much lime so as to form augite or mellinite (1); if to carry much zinc it must also have much iron and little lime, so as to form high-iron olivine (4). It is thus evident that high alumina and zinc, as also high alumina and magnesia are incompatible.

In the work now to be described two melinite-augite series (1) and, one augite-iron-lime olivine series (2) were investigated, both chemically and petrologically. In the series (2) the eutectic or mixture that gives the lowest melting-point occurs when the silicate degree is about 1.65. The observed presence of much augite and practically no iron-lime olivine shows that these latter slags belong on the augite side of the eutectic. Of series (2) the following slag is an example: it contains $SiO_2$, 37.24 per cent.; FeO, 32.2; $Fe_2O_3$ 11.9; $Al_2O_3$, 6.38; CaO, 10.32 per cent. Were all the iron computed as FeO we would have a silicate degree of 1.22 but with one form of the iron ($Fe_2O_3$) present as magnetite, and therefore ineffective in slag formation, the silicate degreetbecomes 1.45. The source of this ferric iron is uncertain; it may come from the converter slag added to the blast-furnace or from the calcines in the furnace charge. Not only is ferric iron ineffective for slag-making but it crystallizes out in the furnace passing in part to the matte, and when in considerable quantity, into the slag, making it mushy, so that the slag may entangle matte containing copper.

From the metallurgical standpoint the most important quality in a slag is that it will readily flow from the furnace, and permit the separation from it of the accompanying matte. This property is closely related to the melting-point and to the viscosity. With coarse material, the formation temperature lies above the melting-point, this latter being that at which the whole mass passes to the fluid state. The viscosity increases with the [illegible] and alumina, and so it is necessary to determine the temperature

at which the slag is sufficiently liquid to flow, that is what amount of superheating is necessary above the melting-point.

Prof. Fulton investigated three series of slags for melting-points and fluidity. Starting with three basal mixtures or slags, he made three series by adding increasing amounts of limestone as shown in the table below. The melting-points lie between 970° and 1220°.

COMPOSITION OF THE BASAL SLAGS.

| No. of Series. | $SiO_2$. | FeO. | $Al_2O_3$. | CaO. |
|---|---|---|---|---|
| (1) | 42.65 | 36.12 | 11.30 | 6.20 |
| (2) | 44.50 | 38.20 | 11.85 | 5.10 |
| (3) | 44.30 | 43.10 | 4.85 | 6.80 |

COMPOSITION AND MELTING-POINT OF THE SLAGS OF THE THREE SERIES INCLUDING THE BASAL ONES.

| | $SiO_2$. | FeO. | CaO. | $Al_2O_3$. | Total. | Silicate Degree. | Melting-point (°C.). |
|---|---|---|---|---|---|---|---|
| Series (1) | 42.65 | 36.12 | 6.20 | 11.30 | 96.37 | 1.40 | 979 |
| | 40.66 | 34.33 | 10.80 | 10.70 | 96.49 | 1.28 | 1011 |
| | 38.80 | 32.60 | 14.95 | 10.02 | 96.37 | 1.19 | 1060 |
| | 36.90 | 31.10 | 18.52 | 9.75 | 96.27 | 1.09 | 1081 |
| | 35.40 | 29.65 | 22.12 | 9.35 | 96.52 | 1.02 | 1137 |
| | 33.92 | 28.48 | 25.14 | 9.00 | 96.54 | 0.96 | 1151 |
| Series (2) | 44.50 | 38.20 | 5.10 | 11.85 | 99.65 | 1.51 | 1050 |
| | 44.00 | 37.80 | 6.14 | 11.73 | 99.67 | 1.48 | 1025 |
| | 43.50 | 37.30 | 7.15 | 11.60 | 99.55 | 1.45 | 988 |
| | 43.20 | 37.00 | 8.16 | 11.51 | 99.87 | 1.42 | 982 |
| | 42.25 | 36.20 | 10.04 | 11.23 | 99.72 | 1.38 | 1010 |
| | 40.50 | 34.65 | 13.60 | 10.75 | 99.50 | 1.28 | 1064 |
| | 38.90 | 33.25 | 16.80 | 10.40 | 99.35 | 1.20 | 1091 |
| | 37.55 | 32.10 | 19.90 | 10.05 | 99.60 | 1.13 | 1103 |
| | 36.20 | 30.81 | 22.56 | 9.67 | 99.30 | 1.06 | 1107 |
| Series (3) | 44.30 | 43.10 | 6.80 | 4.85 | 99.05 | 1.66 | 1000 |
| | 42.65 | 41.51 | 10.29 | 4.69 | 99.14 | 1.54 | 1010 |
| | 41.11 | 40.01 | 13.53 | 4.51 | 99.16 | 1.44 | 1034 |
| | 38.34 | 37.22 | 19.35 | 4.21 | 99.12 | 1.27 | 1097 |
| | 35.92 | 34.97 | 24.43 | 3.94 | 99.26 | 1.13 | 1167 |
| | 33.79 | 32.89 | 28.92 | 3.71 | 99.31 | 1.03 | 1207 |
| | 31.90 | 31.05 | 32.90 | 3.50 | 99.35 | 0.934 | 1186 |

From an inspection of the table, it is apparent that the slags of the lowest melting-points lie between the higher silicate degrees of 1.4 to 1.65, dependent on the base composition; and in the three series here given, carrying no more than from 5 to 13.5 per cent. CaO. Again, considering two slags of the same silicate degree, the one with relatively more lime has the higher melting-point.

With respect to fluidity it was found that in the case of the monosilicate of a silicate degree of 1.0 the amount of superheat above the melting-point was 25° to 40° C. to ensure fluidity; yet when the silicate degree was 1.5 this superheat had to be increased by 150° to 175° C. It can also be seen that the more highly aluminous slags, due to their great viscosity, require much more superheating above the melting-point to obtain

enough fluidity, and hence we see why high aluminous siliceous slags are so much more difficult to work.

Slags approaching the bisilicate (silicate degree 2.0) are looked upon with suspicion, particularly for reverberatory work, though such slags are profitable if they can be worked. However, their formation-temperature and melting-point are unobjectionable, but they do require much superheating for fluidity. There seems to be no good reason why they should not work in furnaces having an ample temperature reserve, such as the large oil-fired reverberatory furnaces.

*Cost of air, as Affected by the Composition of the Matte.*[1]—David H. Brown considers that the work done in converting depends upon the ratios of copper to the iron and sulphur. Thus in a 20-per cent. matte the ratios are for iron 1 to 2.4, for sulphur 1 to 1.25 or of the two together 1 to 3.65. In the same way for a 40-per cent. matte the ratios are 1 to 1.33 and 0.83 respectively and the total 1 to 1.42. Now in copper-converting the air used is a function of the iron plus the sulphur, while the silica needed varies as the iron only.

*Modern Copper Smelting.*[2]—This book consists of a series of nine lectures on the theory and practice of modern copper smelting. It begins with a history of copper, its price and cost of production, and the statistics of copper. This is followed by a discussion of the properties and uses of copper and its compounds. The author then enters upon the subject of copper smelting, both reverberatory and blast-furnace. A chapter is devoted to copper-converting and another to copper refining. The book is a thoroughly modern one.

## Electric Smelting

*Electric Melting of Copper and its Alloys.*[3]—T. A. Hanson believes that the advantages of electric melting are, not only in that the metal loss is diminished and that finely divided metal can be melted, but that oxygen and sulphur can be excluded, thus avoiding contamination. With most careful melting, in crucible-fired furnaces, the metal may take up from 0.02 to 0.05 per cent. of sulphur.

## Blast-furnaces

Franklin Guiterman,[4] in discussing the action of zinc contained in ores smelted in the blast-furnace, says:

Ores containing less than 20 per cent. of zinc cannot be treated at a

[1] *Eng. and Min. Journ.*, XCIV, 842.
[2] By Donald M. Levy, Chas. Griffin & Co., Ltd., London, J. B. Lippincott Co., Philadelphia, 1912, 259 pages, illustrated.
[3] *Eng. and Min. Journ.*, Nov. 30, 1912.
[4] *Mexican Min. Journ.*

profit for the extraction of zinc. Such ores, containing associated gold, silver, lead or copper, are smelted in lead or copper blast-furnaces or reverberatories. Here, however, the zinc in part enters the slag and so is lost. But, due to its presence, other losses occur. Thus, in roasting, it conduces to the loss of silver by volatilization. Again, in the blast-furnace the zinc is reduced, but at once volatilizes to recondense as accretions in the upper portion of the shaft. These accretions cause poor working of the furnace. The reduced zinc oxide, entering the slag, makes this more infusible, and at the usual temperatures of the furnace, renders it viscous. In consequence the slag does not flow freely, and separation from the matte is not complete.

*Charging the Furnace in Pyrite Smelting.*—Levy[1] gives typical tables indicating the variations in smelting. During a 12-hour shift, and at the first smelting, charges of 5000 lb. were fed with some quartz as flux, using 240 lb. of coke per charge. This was aided by an occasional slag-charge, fed with 400 lb. coke per charge. In 12 hours was put through 164 tons of charge with the use of 4.4 per cent. of coke. When reconcentrating, 3500 lb. of matte was used, to which was added 700 lb. of limestone and 1050 lb. of quartz rock. This was varied with an occasional slag-charge of 4000 lb., accompanied by 400 lb. of coke. In 12 hours was put through 339 tons of charge, with the use of 3.6 per cent. coke. It will be observed that the reconcentrating furnace works twice as fast as the first smelting one, due in part to the coarse, easily-melted charge.

*Blast-furnace for Smelting Copper Ores Containing Zinc.*[2]—S. E. Bretherton illustrates a furnace of his design, intended for smelting refractory ores of copper containing much zinc. The furnace is run with a column of ore some 7 ft. above the tuyères, and with a hot top, so that the zinc shall be freely volatilized. The width at the tuyères is 42 in., in the shaft, 54 in. at the closed top, above the feed-floor 78 in. The top, surmounted by a sheet-iron horizontal drum, is 12 ft. diameter. From this latter leads off a down-take 6 ft. diameter. The tuyères can be independently shut off. The slag-spout, of the open-breast kind with continuous flow, is placed at the middle of the side of the furnace. An independent matte-tap is at one end. The forehearth is 8 ft. diameter by 5 ft. deep, outside dimensions.

*Consumption of Fuel in the Smelting of Copper Ores.*[3]—G. Ralli discusses the question of the causes of waste of fuel in smelting in which it is asserted that the total losses are 1000 cal. per kilo whereas they should be no more than 500 to 700 cal. Such losses may occur in: heat carried off in the escaping gases, in the jacket water, by radiation,

[1] "Modern Copper Smelting," p. 187.
[2] *Min. and Sci. Press*, CIV, 244.
[3] *Revue Universelle des Mines et de la Metallurgie*, XXXIV, 213, XXXV, 1.

by imperfect combustion, in the slag and by chemical reactions. The article is illustrated by microphotographs.

Pyrite smelting and the presence of carbonates will account for not more than 5 per cent. of the total gases. Experimentally it has been found that in 1.4 seconds the hot gases will give up 90 per cent. of this heat so that a great increase of the smelting column saves practically no more of the heat than a low one. With a cool top and the gases escaping at 180 to 200° C., as is the case with an easily fused charge, the heat loss will be 30 to 40 cal. per kilo; with a more refractory charge and the gases escaping at 300° C. the loss will rise to 80 to 100 cal. Jacket loss per square meter of jacket is about 9 cal. and the total loss may be given at 60 cal. per kilo of charge smelted. Radiation loss is 8 to 12 cal.; crucible loss is negligible. At Balia, with coke on the charge containing 6.3 per cent. pure carbon, it was found that no CO was produced, while at 7.2 per cent. the gases contained about 4 per cent. CO.

To determine the interior resistances and their distribution throughout the column the author has measured the pressure at different heights. The pressure was measured by means of a 7/8 in. pipe 20 ft. long inserted into the charge-column and connected to a pressure gage; the tube descending with the charges. The temperatures of the smelting column are measured by means of a thermo-element at the end of a similar tube but gave disaccordant results. From the pressure and temperature measurements a fusion zone is shown, beginning 20 in. above the tuyère-level and about 40 in. thick.

With a furnace in operation, to double the volume of the air takes eight times the horse-power, the work varying as the cube of the volume. When smelting 86 tons with a pressure of 12 in., 5.8 h. p. was needed and at 28 in. there was needed 16.2 h.p.

The theoretical temperature of combustion of the coke is from 1730° to 2620° C., but because of disassociation and transmission loss it does not reach this figure. Thus, when the gases contained equal volumes of CO and $CO_2$ the theoretical temperature would be 2200° but by actual measurement only 1700° C. The subjoined table gives the percentages of the gas analyses at different heights in the furnace. As shown, there is a large excess of air at and immediately above the tuyères.

| Level. | $SO_2$. | $CO_2$. | O. | CO. | N. |
|---|---|---|---|---|---|
| ..... | 0.4 | 9.2 | 7.6 | 6.7 | 76.0 |
| ‘‘yères..... | 0.6 | 13.2 | 3.5 | 4.7 | 78.0 |
| /ères..... | 2.2 | 17.3 | 1.1 | 2.9 | 76.5 |
| ve tuyères..... | 3.9 | 21.8 | 0.7 | 1.6 | 71.9 |

Taking the total heat of fusion at 343° C., and that 64 per cent. of he charge is slag, we have $343 \times 0.64 = 220°$ C. as the loss per kilo of harge. With a difficultey fusible ore this may be as much as 320° C.

In taking account of the calories absorbed by the different furnace eactions, the loss would vary from 151 to 177 cal. per kilo of charge.

At Mansfelt, Germany, where a high fuel is required, of the 1680 calories used only 660 were needed in theory, largely due to incomplete burning of the coke into CO.

*Improved Trap-spout for Blast-furnace.*[1]—Arturo Poupin illustrates in a half-tone, and in the accompanying Fig. 3, an improved spout as used at Cananea. The tap-jacket opening is large, and it is set well above the interior of the spout. This space may be filled with brasque. Thus is avoided the chilling effect of the spout when placed close to the tap-hole, also a large tap-hole is more easily kept open.

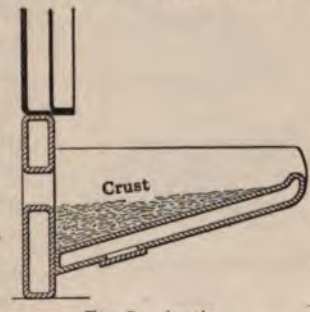

FIG. 3.—Austin.

*Jacket.*—The Traylor Engineering Co., Allentown, Pa., now make a wrought jacket in which the tube forming the tuyère-aperture is made an integral part of the inner or fire-sheet. The angle-iron bracing between the inner and outer sheets is rivetted to the outer sheet and spot-welded to the inner one. The jacket will stand readily a pressure of 20 lb. per square inch, is rigid and no rivets are exposed on the fire-surfaces.

*The Feld Centrifugal Gas Washer.*[2]—For the recovery of the flue-dust remaining after the usual settling in flues, the Feld Washer is proposed. Fig. 4 represents the machine. It consists of a vertical tower composed of six chambers through which the gas passes upward, being in each chamber brought in contact with water projected horizontally from a rapidly revolving set of cones. From a central pan these pick up the water, which is then thrown outward as a body of mist so thick that it presents a foam-like appearance. The gas is sucked upward through four gas passages at each chamber, and is carried upward by the whirling motion of the cones. The water passes downward from chamber to chamber.

At the bottom the liquid, still in agitation, passes away, while the gas escapes at the top. The power needed for the washer is moderate. The smallest size with three chambers, capable of treating 170 cu. ft. per minute, can be driven by 0.5. h.p. while the largest size, dealing with 31,000 cu. ft. per minute, would require 25 h.p. More than

[1] *Eng. and Min. Journ.*, XCIV, 785.
[2] *Met. and Chem. Eng.*, X, 436.

97 per cent. of the dust is extracted in passing through one washer. The gases arrive at a high temperature, and cooling is effected down to 5° C. above the temperature of the water. In the case of such a washer at a lead-plant a recovery of 97 per cent. was effected, yielding a wet cake containing about 70 per cent. of lead.

*Width of Blast-Furnace.*[1] —The practice of the Compagnie du Boléo, using narrow furnaces of 42-in. width, is contrasted with that at the Great Falls plant of the Anaconda Copper Mg. Co.,[2] where a furnace 84 in. wide has been developed. To do so, in the latter case the cross-section of the furnace has been modified to resemble the iron blast-furnace, so that a throttling action is secured at the throat. This is believed to cause the blast to spread in the smelting zone under pressure rather than to depend on the initial velocity of penetration. So far as penetration due to initial velocity is concerned the reviewer feels sure that no such result is attained, the blast seeking the path of least resistance. Where the central zone receives the coarser charge the blast is bound by preference to seek that region. The use of this design has permitted the lowering of the blast-pressure to 20 to 25 oz. per square inch, and the furnace will run for a week at a time without barring of crusts at the tuyères. The wider furnace has proportionately less radiating surface than the narrow one.

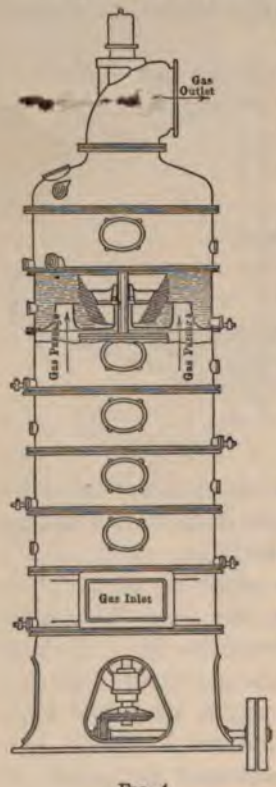


FIG. 4.

*Turbo-blowers at Mt. Morgan.*[3]—The installation includes four C. H. Parsons & Co's. multiple-stage centrifugal blowers for the blast-furnaces and three for the converters, all electrically-driven. Each furnace blower delivers 18,000 to 20,000 cu. ft. of air per minute at 64 oz. per square inch pressure, and is driven by a 500-volt direct-current variable-speed motor, its speed varying from 2200 to 2700 revolutions per minute. Each converter blower has a capacity of 5000 cu. ft. of free air per minute at 12 lb. per square inch pressure, and is driven at 2700 to 3050 revolutions per minute. The air for the blowers is drawn from a chamber beneath the floor, which is connected to a tower, the inlet of which is 30 ft. above the ground,

[1] *Min. and Sci. Press*, CIV, 685.
[2] A. E. Wheeler, Supt., and M. U. Krecji, metallurgist.
[3] *Min. and Sci. Press*, CV, 500.

thus securing freedom from dust. Air is delivered beneath the machines, and is connected to the main blast-pipe by branch pipes provided with valves.

## Reverberatory Furnaces

*Distinctive Features of the Modern Reverberatory Furnace.*[1] —These are (1) size in length and width; (2) solid bottom of slag with fused-in quartz bottom; (3) structural steel conker-plate for the bridge-wall; (4) frequent charging, both of ore and fuel; (5) flowing the slag, rather than skimming by rabble; (6) a deep body of matte constantly maintained in the furnace to assist in melting and distributing the charge, there being no leveling of the charge by using a rabble; (7) a thick roof to as much as 15 to 20 in.; (8) fettling the furnace in many plants as seldom as once a month; (9) practically continuous operation; (10) recovery of heat by aid of waste-heat boilers; (11) recovery or unburned coal or cinder, when soft coal is used; preheating the air by passing it through flues beneath the furnace, around the fire-box, the stack, or the outlet flue has been unsuccessfully tried. Forced-blast below the grate has often failed.

*Reverberatory Performance in Relation to Size.*[2]—The diagram, Fig. 5, page 245, shows how the output, the coal used, and the cleanness of the slag are functions of the length of the furnace. Thus, with a furnace of 50 ft. in length, the output was 122 tons in 24 hours, the ratio of coal to charge (not including some 5 per cent. of limestone) was as one to 2.75, or 36 per cent, while the slag carried 0.5 per cent. copper, these figures being the result of one year's operation. With a furnace 116 ft. long, the daily output was increased to 270 tons, the ratio of coal to charge 4.19 or 24 per cent., the slag contained 0.36 per cent. copper, all being the average of figures for four years. The curves of the diagram indicate, that in respect to coal economy, the maximum of performance has been reached at 100 ft. but that with greater length, more charge is smelted and a cleaner slag obtained. This latter result is doubtless due to the longer time and the extra distance in the furnace through which settling proceeds.

*Record Reverberatory Performance.*[3]—The following performance of an oil-fired furnace, having hearth dimensions 19 by 121 ft. at the Steptoe Valley plant, McGill, Nev., Dec. 17, 1911, is given by the superintendent S. S. Sorenson.

[1] *Eighth Int. Cong. Appl. Chem.*, III, 113.
[2] *Int. Cong. of Appl. Chem.*, III, 128.
[3] *Eighth Int. Cong. Appl. Chem.*, III, 123.

## PERFORMANCE OF REVERBERATORY FURNACES IN AMERICA.[1]

| | Anaconda (Montana). | Cananea (Mexico). | Great Falls (Montana). | Garfield (Utah). | Steptoe (McGill) (Nevada). | | Tooele (Utah). |
|---|---|---|---|---|---|---|---|
| | | | | | (Coal) Fired. | (Oil) Fired. | |
| Number of furnaces | 8 | 2 | 3 | 6 | 5 | | 5 |
| Average tonnage per day | 253— (229.5 T.M.) | 192.3 (174.4 T.M.) | 200— (181.4 T.M.) | 240— (217.7 T.M.) | 239— (216.8 T.M.) | 322— (292.1 T.M.) | 225— (204.1 T.M.) |
| Average weight of charge | 15 tons (13.6 T.M.) | 7½ to 9 tons (6.8–8.2 T.M.) | 35 tons (31.75 T.M.) | 6 to 24 tons (5.44–21.77 T.M.) | 14 tons (var.) (12.7 T.M.) | 14 tons (var.) (12.7 T.M.) | 13 tons (11.8 T.M.) |
| Average tons charge per ton fuel | 4.25 | 5.86 | 2.00 | 3.50 to 4.00 | 3.24 | 5.80 | 3.80 |
| Average temperature of charge entering furnace | 950° F. (est.) (510° C.) | 500° to 550° F. (260°-288° C.) | 788° F. (420° C.) | 400° to 700° F. (204°–371° C.) | 500° F. approx. (260° C.) | 500° F. (260° C.) | 750° F. (399° C.) |
| Kind of fuel used | Run of mine coal | California crude oil. | Producer gas | Bituminous coal | ..... | California crude oil | Run of mine coal |
| Character of charge: | | | | | | | |
| Calcine (hot) | 84.95 per cent. | 50.0 per cent. | 66.00 per cent. | 75 to 78 per cent. | 61.3 per cent. | 56.8 per cent. | 95.00 per cent. |
| Calcine (cold) | ..... | ..... | ..... | 19 to 16 per cent. | ..... | ..... | ..... |
| Flue dust | 15.05 | 50.00 | 34.00 | 6.00 | 1.2 | 1.4 | 5.00 |
| Conv. slag | ..... | ..... | ..... | ..... | 9.8 | 7.1 | ..... |
| Secondaries (cold) | ..... | ..... | ..... | ..... | 12.5 | 15.2 | ..... |
| Flux and fettling ores (cold and wet) | ..... | ..... | ..... | ..... | 12.5 | 19.5 | ..... |
| Draft in inches of water at bridge | 0.75 in.–1 in. (1.9–2.54 cm.) | (No Data) | 0.2 in. (0.5 cm.) | 0.6 in. (1.5 cm.) | 0.2 in.–0.5 in. (0.5 cm.–1.3 cm.) | | 0.8 in. (2 cm.) |
| Draft in inches of water at throat | 1.3 in.–1.7 in. (3.8–4.8 cm.) | 0.13 in. (0.33 cm.) | 0.3 in. (0.76 cm.) | 0.8 in. (2. cm.) | 0.7 in.–1.2 in. (1.78–3.05 cm. | 0.9 in. (2.29 cm.) | 0.6 in. (1.52 cm.) |
| Draft in inches of water—main flue beyond boilers | 1.5 in.–2 in. (3.81–5.08 cm.) | 0.9 in. (2.29 cm.) | 1.5 in. (3.81 cm.) | 1.65 in. (4.19 cm.) | 1.25 in. (3.18 cm.) | | 1.75 in. (4.45 cm.) |
| Temperature of gas at bridge | (225.54 m.) 2800° F. (1538° C.) | (60.35 m.) 2700°–2800° F. (1482°–1538° C.) | (234.07 m.) 2650° F. (1455° C.) | (153.61 m.) 2600°–2800° F. (1427–1538° C.) | (96.55 m.) 2700°–3000° F. (Est.) (1482°–1649° C.) | | (125.57 m). 2600° F. (1427° C.) |
| Temperature of gas at throat | 2200° F. (1205° C.) | 2300°–2400° F. (1260°–1316° C.) | 2550° F. (1397° C.) | 2000° F. (1094° C.) | 2200° F. (approx.) (1205° C.) | | 2000° F. (1093° C.) |
| Temperature of gas at far side of boilers | 680° F. (360° C.) | 500° F. (260° C.) | (No boilers) | 900° F. (482° C.) | 800° F. (approx.) (427° C.) | | 775° F. (412° C.) |
| Average boiler horse-power per furnace from waste heat | 560 h.p. (568 C.V.) | 971 h.p.[2] (984 C.V.) | None | 330 h.p. (335 C.V.) | 486 h.p. (493 C.V.) | 632 h.p. (641 C.V.) | 390 h.p. (396 C.V.) |
| Per cent. fuel recovered as steam | 32.81 | 56.62 | None | 27.00 | 32.3 | 33.8 | 41.2 |
| Per cent. fuel recovered from ashes | 7.50 | None | 5.00 | 9.50 | 5.05 | ..... | None |
| Ratio of concentration | 4.79 | 4.96 | 4.30 | 3.50 | 3.31 | 3.40 | 9.00 |
| Tons charge per million b.t.u. | 0.182 | 0.1574 | 0.115 | 0.147–0.167 | 0.122 | 0.171 | 0.165 |

[1] *Int. Cong. Appl. Chem.*, III, 113.
[2] Economisers are installed at this plant beyond boilers.

DIMENSIONS OF REVERBERATORY FURNACES IN AMERICA.[1]

| | Anaconda (Montana). | Cananea (Mexico). | Great Falls (Montana). | Garfield (Utah). | Steptoe (McGill) (Nevada). | | |
|---|---|---|---|---|---|---|---|
| | | | | | (Coal) Fired. | (Oil) Fired. | |
| Dimensions of hearth | 111 ft.–8 in. × 19 ft. (34.04 × 5.79 m.) | 100 ft. × 19 ft. (30.48 × 5.79 m.) | 41–6 × 15 ft. 9in (12.65 × 4.80m | 112 ft. × 19 ft. (34.14 × 5.79 m.) | 120ft. – 10 in. × 19 ft. (36.83 × 5.79 m.) | | 102 ft. × 19 ft. (31.09 × 5.79 m) |
| Dimensions of fire box | 7 ft. × 16 ft. (2.13 × 4.88 m.) | None. | Gas fired. | 7 ft. × 18 ft. (2.13 × 5.49 m.) | None. | | 7 ft × 16 ft. (2.13 × 4.88 m.) |
| Top of grate bars to top of bridge. | 24 in. (61 cm.) | None. | Gas fired. | 33 in. (84 cm.) | 33–1–4 in. (84 cm.) | ..... | 40 in. (102 cm.) |
| Top of grate bars to under side of roof. | 70 in. (178 cm.) | None. | Gas fired. | 45 in to 48 in. (114–122 cm.) | 85–3–8 in. (217 cm.) | ..... | 78 in. (198 cm.) |
| Height of "verb" or vulcatory above skim plate. | 36 in. (91 cm.) | 36–1/2 in. (93 cm.) | Gas fired. | 36 in. to 38 in. (91–97 cm.) | 36 in. (91 cm.) | | 36 in. (91 cm.) |
| Dimensions at throat of furnace. | 7 ft. × 4 ft. – 11 in. (2.13 × 1.50 m.) | 7 ft. × 1 ft.–9 in. (2.13 × 0.53 m.) | Gas fired. | 7 ft. × 3 ft.–3 in. (2.13 × 0.99 m.) | 6 ft.–10 in. × 3 ft. (2.08 × 0.91 m.) | | 7 ft. × 4 ft.–1 in. (2.13 × 1.24 m.) |
| Dimensions of flue beyond throat (damper flue). | 36 in. × 54 in. (91 × 137 cm.) (natural draft.) | 7 ft. × 6 ft. (213 × 183 cm.) | ..... ..... | 39 in. × 64 in. (99 × 163 cm.) | (Not given.) ..... | | 36 in. × 60 in. (91 × 152 cm.) |
| Dimensions of main flue | 15 ft. × 20 ft. (4.57 × 6.10 m.) | 10 ft. × 12 ft. (3.04 × 3.66 m.) | 20 ft. × 48 ft. (6.1 × 14.63m) | 19 ft.–8 in. × 22 ft.–6 in. (5.99 × 6.86 m.) | 29 ft.–3 in. × 8 ft.–6 in. (8.91 × 2.59 m.) | | 18 ft. × 20 ft. (5.49 × 6.1 m.) |
| Dimensions of chimney | 300 ft. × 30 ft. (91.44 × 9.14 m.) | 187 ft. × 12 ft.–6 in. (57 × 3.81 m.) | 506 ft. × 50 ft. (154.22 × 15.23 m.) | 300 ft. × 30 ft. (91.44 × 9.14 m.) | 300 ft. × 15 ft. (91.44 × 4.57 m.) | | 350 ft. × 25 ft. 106.68 × 7.62 m. |
| Height of top of stack above grate | 740 ft. | 198 ft. | 768 ft. | 504 ft. | 316 ft.–9–1/2 in. | | 412 ft. |

[1] *Int. Cong. Appl. Chem.*, III, 113.

DETAILS OF MODERN REVERBERATORY FURNACE SMELTING IN AMERICA.[1]
Analyses of Materials Used and Produced.

| | | Copper, Per cent. | Silver Ozs. (Per Ton). | Gold Ozs. (Per Ton). | Per cent. $SiO_2$. | Per cent. Fe & Mn. | Per cent. CaO. | Per cent. S. | Per cent. $Al_2O_3$. |
|---|---|---|---|---|---|---|---|---|---|
| Charge | Anaconda | 9.31 | 6.43 | 0.028 | 28.63 | 26.46 | 3.50 | 7.34 | 5.22 |
| | Cananea | 6.43 | 2.22 | 0.14 | 26.96 | 31.34 | 2.58 | 9.59 | 5.54 |
| | Great Falls | 9.47 | 3.77 | 0.0236 | 22.50 | 26.91 | 4.20 | 11.40 | 6.40 |
| | Garfield | 12.00 | 3.50 | 0.16 | 30.00 | 22.50 | 11.50 | 10.50 | 4.50 |
| | Steptoe (McGill). (coal) fired | 13.60 | 0.401 | 0.078 | 26.80 | 25.90 | 5.80 | 9.50 | 5.30 |
| | (oil) fired | 13.10 | 0.345 | 0.078 | 27.60 | 24.10 | 5.40 | 9.30 | 6.90 |
| | Tooele | 2.90 | 3.80 | 0.11 | 30.50 | 35.00 | 3.80 | 6.50 | ..... |
| Slag | Anaconda | 0.39 | 0.19 | 0.0006 | 39.68 | 32.83 | 4.62 | 0.91 | 7.03 |
| | Cananea | 0.35 | 0.11 | ..... | 37.44 | 33.58 | 3.83 | 1.08 | 7.96 |
| | Great Falls | 0.35 | 0.12 | trace | 42.50 | 23.64 | 11.60 | 0.48 | 9.40 |
| | Garfield | 0.45[2] | 0.08 | trace | 46.50 | 20.58 | 17.50 | 1.00 | 5.50 |
| | Steptoe (McGill) (coal) fired | 0.45[2] | 0.06 | 0.005 | 40.20 | 28.90 | 10.50 | 0.40 | 7.60 |
| | (oil) fired | 0.50[2] | 0.02 | 0.007 | 42.00 | 25.90 | 10.90 | 0.20 | 8.00 |
| | Tooele | 0.43[2] | 0.45 | 0.008 | 40.50 | 36.93 | 4.00 | ..... | ..... |
| Matte | Anaconda | 41.68 | 28.40 | 0.130 | 0.27 | 26.54 | ..... | 25.76 | ..... |
| | Cananea | 31.91 | 11.34 | (Insl) 0.07 | 0.54 | 37.17 | ..... | 26.87 | ..... |
| | Great Falls | 31.96 | 12.00 | 0.085 | No data | 35.54 | ..... | 26.70 | ..... |
| | Garfield | 42.00 | 10.00 | 0.50 | ..... | 27.00 | ..... | 26.00 | ..... |
| | Steptoe (McGill). (coal) fired | 41.76 | 1.25 | 0.25 | 0.70 | 29.00 | ..... | 25.10 | ..... |
| | (oil) fired | 42.99 | 0.91 | 0.22 | 0.50 | 29.10 | ..... | 24.80 | ..... |
| | Tooele | 23.00 | 27.50 | 0.85 | 0.50 | 43.00 | ..... | 26.50 | ..... |

| | | Per cent. moisture | Per cent. V.C.M. | Per cent. Fixed carbon. | Per cent. Ash. | B.t.u. (dry). | B.t.u. (wet). |
|---|---|---|---|---|---|---|---|
| Fuel | Anaconda | 6.13 | 36.28 | 45.42 | 12.17 | 12,390— | 11,710— |
| | Cananea | ..... | ..... | ..... | ..... | No data | 18,600— |
| | Great Falls | 7.70 | 23.70 | 46.00 | 28.60 | No data | 9,382— |
| | Garfield | 8.00 | 39.40 | 46.40 | 6.20 | No data | 12,000— |
| | Steptoe (McGill) (coal) fired | 2.00 | 39.10 | 51.50 | 7.40 | 13,000— | ..... |
| | (oil) fired | ..... | ..... | ..... | ..... | 18,220— | ..... |
| | Tooele | 6.00 | 38.00 | 45.00 | 11.00 | ..... | 11,500— |

| | Per cent. $CO_2$ | Per cent. CO | Per cent. $CH_4$ | Per cent. H | Per cent. N |
|---|---|---|---|---|---|
| Gas—Great Falls | 10.50 | 15.80 | 2.20 | 13.70 | 57.80 |

In 24 hours there was put through 666 tons of charge composed of calcines 60.1 per cent. at a temperature of 260° C. seconds 16.8; hot slag from the converters, 9; fettling material, 3.9; lime-rock, 9.6; and flue-dust, 0.6 per cent. This was melted by 421 barrels of crude California oil being 0.63 barrels per ton of charge or 9 1/4 per cent. fuel and equivalent to 124 tons of coal, which would equal 18.6 per cent. of the charge. The resultant slag contained $SiO_2$, 44 per cent.; FeO, 34.3; CaO, 8.6, and $Al_2O_3$

[1] *Cong. of Appl. Chem.*, III, 118.
[2] Converter slag is poured into Reverberatories at these plants, thus raising copper assay, as only 75 per cent. in converter slag is recovered.

7.4 per cent. The matte contained 40.4 per cent. of copper. The draft at the back or fire-end was 0.35, at the throat 0.83 and at the stack 1.25 in. of water. The temperature of the escaping gases at the verb was

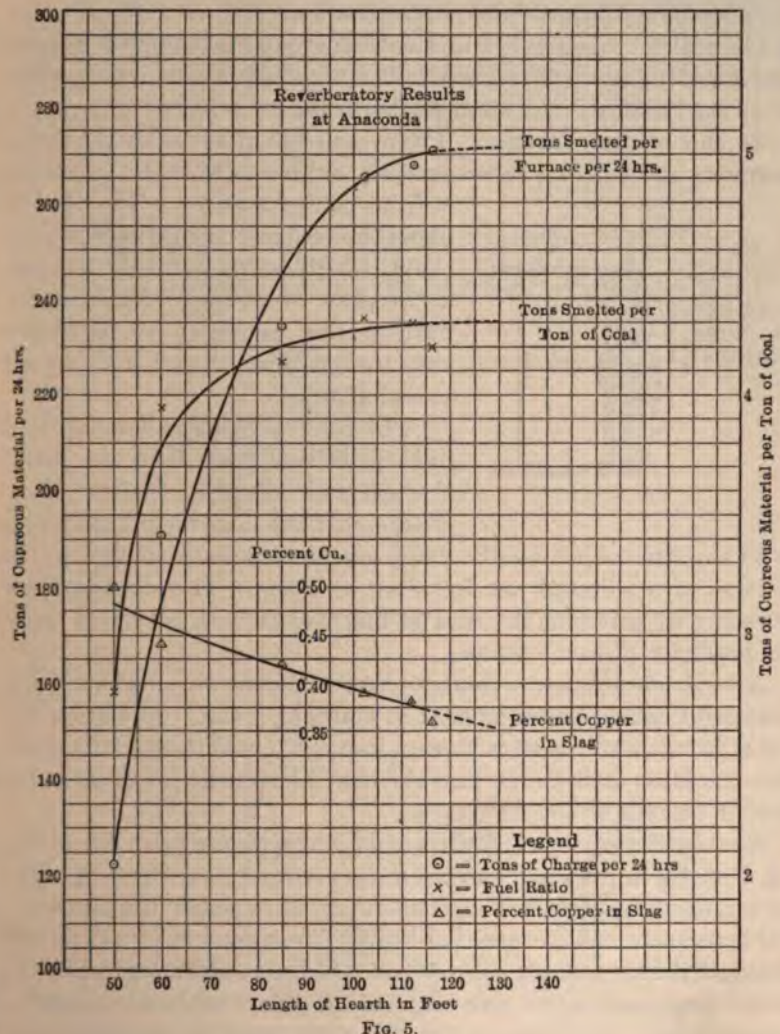


FIG. 5.

1045° C., or just at the formation temperature of the slag. The performance for so short a period is open to criticism in that melting might not have been complete at the end of the trial, or that errors might have crept in the weights. Even so, the results are most extraordinary. It will

be noted from the table that the average performance is 322 tons daily.

*Pulverized Coal for Reverberatories.*[1]—The Canadian Copper Co., Copper Cliff, Ontario, is using coal in its 19 by 112-ft. furnaces. Thus far the company is pleased with the results.

The coal is broken to 1/4-in. size then ground to 200-mesh in Raymond impact pulverizers. The powder is sucked by a fan into a settler on top of the building, and when settled is fed by a screw-conveyor to bins at the end of each furnace. From each bin it is taken by five screw-conveyors and fed to a corresponding number of burners, where it drops in front of the nozzles, The blast issuing blows the coal into the furnace in form of a cloud, which burns in much the same way as a spray of oil-fuel. Each of the five burners can be operated independently, and the amount of coal and air may be varied at will.

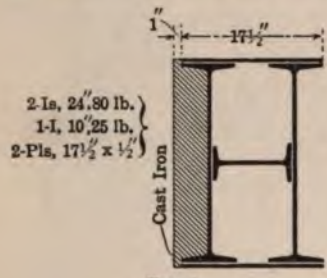

FIG. 6.

The objections urged against the use of pulverized coal have been the settling of the ash and unburned fuel on top of the charge, and the clogging of flues with ashes. As to the first objection the company melts a basic charge so that the addition of a siliceous ash is rather welcome. The second objection is overcome by grinding the coal so fine that the ash is carried away with the products of combustion.

*Reverberatory-furnace Conker-plate.*[2]—Piercy E. Barbour describes a sucessful conker-plate, as used at Garfield, Utah. As shown in Fig. 6 it is a boxed-beam faced with cast-iron. To cool the beam a small pipe from the blast-main blows into the boxed-beam the jet of air inducing a through current of air.

*Reverberatory Furnace, Boilers and Flues at the Garfield, Utah, Plant.*[3]—Fig. 7 shows in plan and elevation the reverberatory furnace, and Fig. 8 the arrangement of waste-heat boilers and flues which dispose of the gases of this furnace The furnace has hearth dimensions 19 by 112 ft. As first arranged, it had a closed ash-pit and undergate blast, but when the flue-system was modified to give better draft this was abandoned in favor of natural draft. As shown in Fig. 8, the flue from the reverberatory leads to two boilers each of 350 h.p. These boilers may be by-passed by a flue leading to a brick catenary flue 27 ft. 2 in. in width by 17 ft. 3 in. high, common to all the furnaces.

[1] *Min. Mag.*, VI, 380. From *Canadian Min. Inst.*, March 1912; *Int. Cong. Appl. Chem.*, III, 124.
[2] *Eng. and Min. Journ.*, Sept. 28, 1912.
[3] *Int. Cong. Appl. Chem.*, III, 130; MINERAL INDUSTRY, XV, 275, XVII, 244.

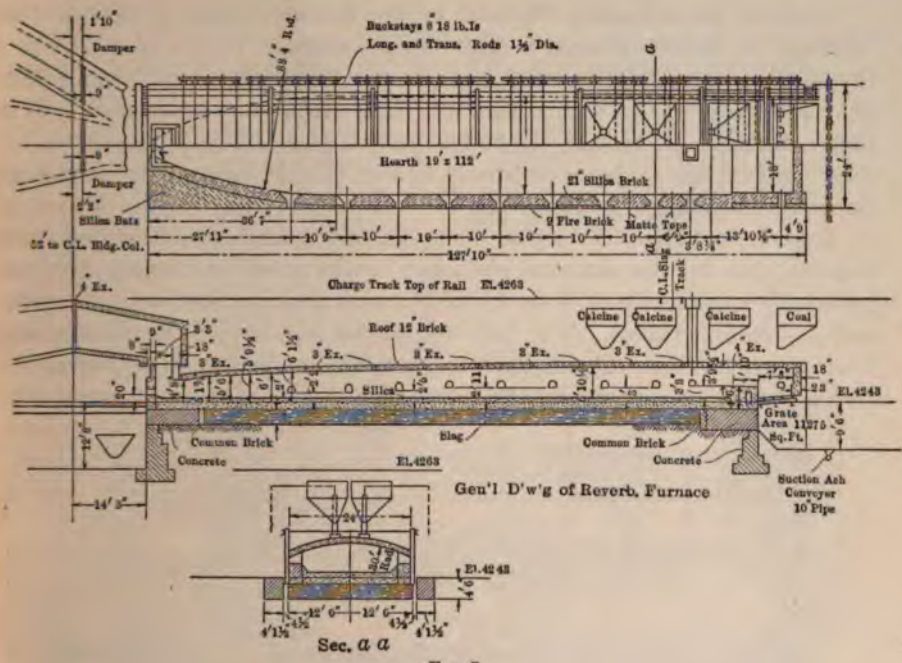
Buckstays 8 18 lb. Is
Long. and Trans. Rods 1¾" Dia.
Hearth 19' x 112'
21" Silica Brick
9 Fire Brick
Matte Tap
Silica Bats
52' to C.L. Bldg. Col.
127'10½"
Charge Track Top of Rail El. 4263
C.L. Slag Track
Calcine
Calcine
Calcine
Coal
Roof 12" Brick
Silica
Slag
Common Brick
Concrete
El. 4263
Grate Area 11275 Sq. Ft.
El. 4243
Suction Ash Conveyer 10" Pipe
Gen'l D'w'g of Reverb. Furnace
Sec. a a

FIG. 7.

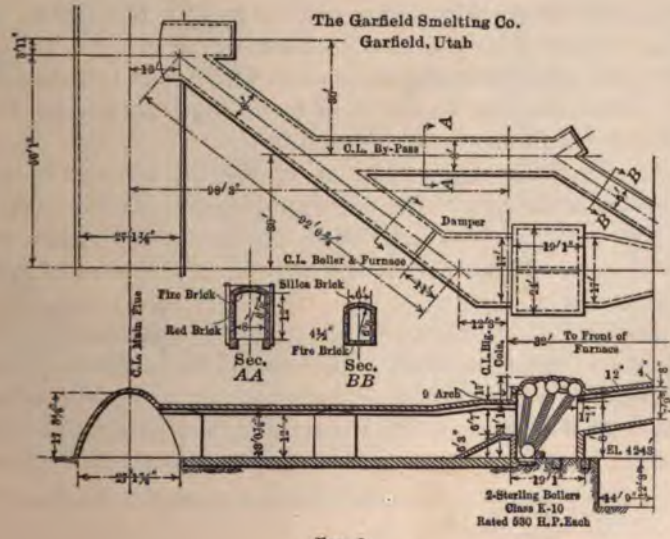
The Garfield Smelting Co.
Garfield, Utah
C.L. By-Pass
Damper
C.L. Boiler & Furnace
Fire Brick
Silica Brick
Red Brick
4½" Fire Brick
Sec. AA
Sec. BB
C.L. Main Flue
To Front of Furnace
C.L. Brg. Cols.
9 Arch
EL. 4243
2-Sterling Boilers
Class K-10
Rated 530 H.P. Each

FIG. 8.

*Oil-fired Reverberatory Furnace of the Steptoe Valley Smelting and Mining Co., McGill, Nevada.*[1]—Fig. 9 represents, in plan and elevation, the oil-fired furnace 19 by 121 ft. It is charged through six drop-holes near the back or fire end. A variety of burners have been used, but a simple home-made burner has given the best results. Seven burners are used per furnace. Dimensions and figures of performance are given in the tables, pages 242 to 244.

*Regenerative Reverberatory or Open-hearth Furnace at Great Falls.*[2]—In Fig. 10 is shown the plan and elevation of this gas-fired furnace, having hearth-dimensions 15 ft. 9 in. by 42 ft., with a checker-work flue-system and controlling valves. The fuel is producer-gas, but the producers are located too far from the furnaces to get the best results. New regenerative furnaces are contemplated for this plant, in which the producers will

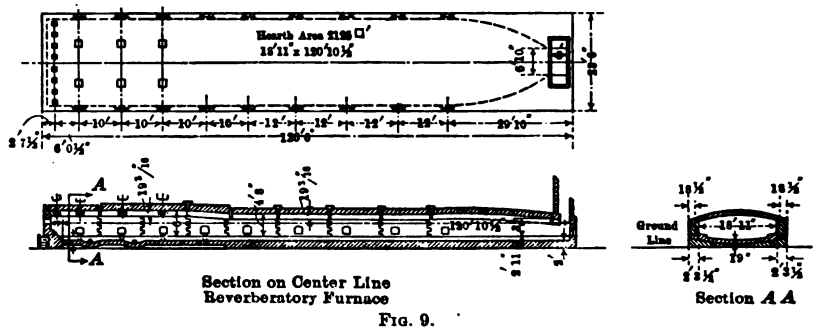


FIG. 9.

be placed close to the furnaces, and thus greater fuel efficiency will be obtained. (It has been objected to these furnaces in the past that the flue-dust made while dropping the charge would tend to choke the checker-work. Provision can, however, be made to minimize this drawback.)

*Reverberatory Plant of the Copper Queen Consol. Mg. Co., Douglas, Arizona.*[3] Fig. 11 is a general plan of the roasters and reverberatory system for the treatment of the fine sulphide ore. The roaster building, 50 by 73 ft. 6 in., contains six McDougal roastsers, which connect to the dust chamber 43 by 144 ft. and thence by a short flue to the 25-ft. main stack.

The reverberatory system consists of three oil-fired furnaces 90 ft. long, the gases discharging into a flue common to the three. Thence they pass through four waste-heat boilers and through four economizers, thence to a dust-chamber 43 by 132 ft., and finally by a short flue to the main stack. The long flue, leading to a distant stack, is dispensed with.

[1] *Int. Cong. Appl. Chem.*, III, 132; MINERAL INDUSTRY, XX, 189, XIX, 182, 183, XVIII, 204.
[2] *Int. Cong. Appl. Chem.*, III, 116.
[3] *Eighth Int. Cong. Appl. Chem.*, XII, 134.

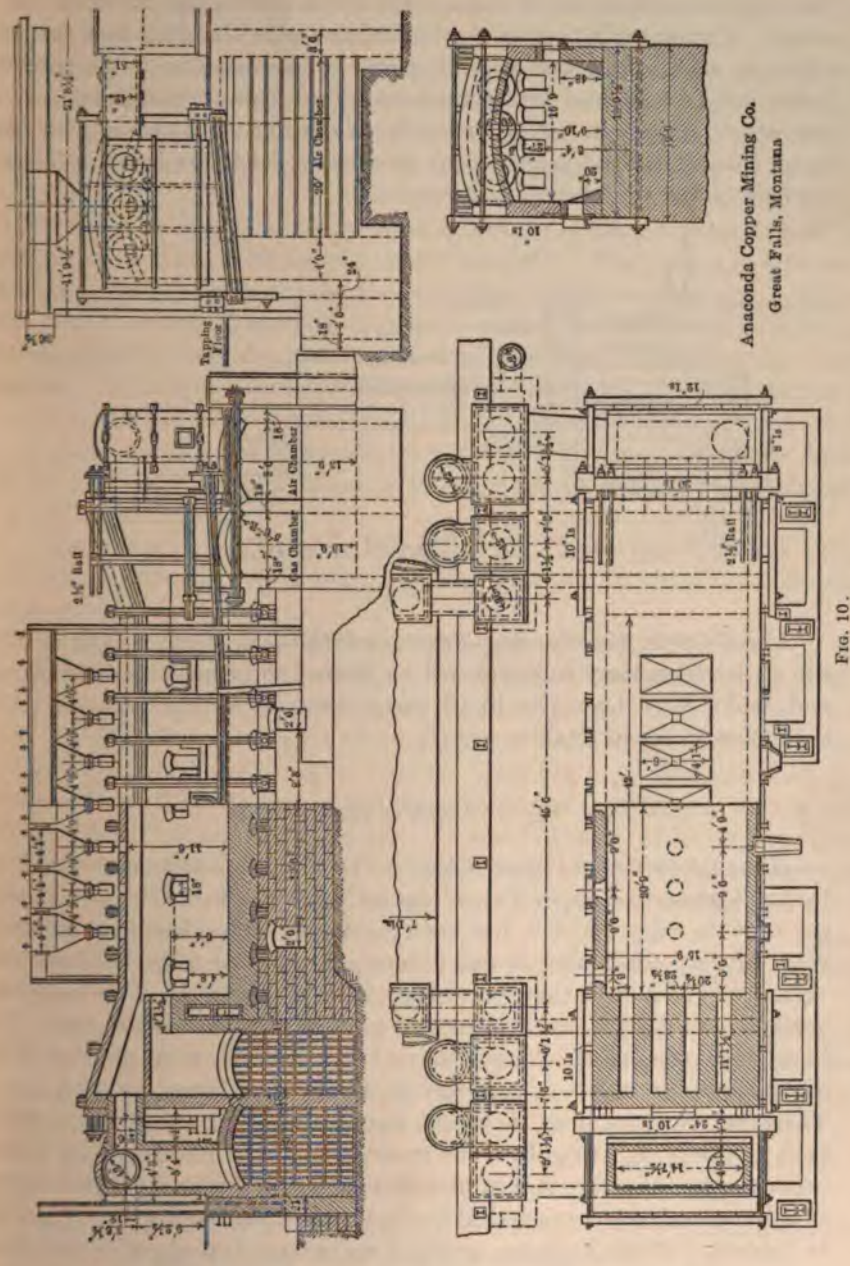


FIG. 10.

The slag is drawn off at the front of the furnace into slag-cars, and hauled away. The matte is tapped as required to ladles standing in a ladle-pit which is situated at the adjoining end of the smelter building. The ladles are hoisted and transferred by crane from the ladle pit to the converters. The roasted ore taken from the roaster building is brought in by calcine cars at such height that they discharge into the charge-hoppers of the reverberatory furnaces.

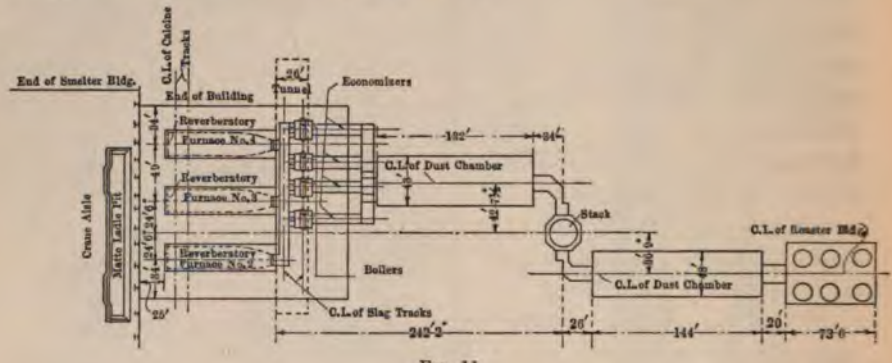


FIG. 11.

*Use of Oil for Reverberatory Furnaces at Garfield, Utah.*—Early in 1913, the six reverberatory furnaces will be altered to burn oil instead of coal, and tanks have been put in to carry a supply of the crude oil. This is the first plant in Utah to use oil.

## CONVERTERS

*Basic Converters at Copper Cliff.*[1]—The copper-nickel matte produced by the Canadian Copper Co., Copper Cliff, Ont., formerly as high as 40 per cent. in copper-nickel, has been gradually falling to as low as 20 per cent. in that alloy, and it was accordingly decided to install basic converters. The first of these was blown in in April, 1911. Five basic converters now do the work formerly done by the acid-lined ones. The basic converter, of the Pierce-Smith type, is 37 ft. 2 in. long by 10 ft. diameter of the shell, and is revolved on four tread-rings, 12 ft. diameter. There are two openings, a throat for the escaping gases and a spout, both opposite to, but above, the tuyère-line at the middle of its length, because when the throat was placed near one end a gradual building-up of siliceous material occurred at that point, tending to close it. There are 44 tuyères, 1.25 in. diameter, spaced 7 in. centers, but opposite the throat there are no tuyères. The length inside the magnesite lining is 33 ft. 3 in.,

[1] *Trans. Canadian Min. Inst.*, March, 1912; *Min. Mag.*, VI, 380.

the bottom lining is 24 in. thick, the back or tuyère wall 18 in., the front 15 in., the top 12 in., while around the tuyères it is 24 in. thick. The converter is turned by means of wire ropes connected to piston-rods moving in hydraulically operated cylinders, oil being, however, used instead of water because of the cold winter climate. Since the plant is electrically driven safety devices have been adopted to prevent mishaps in case the current fails.

The initial charge of a converter is 60 tons of blast-furnace matte, to which is added about 10 per cent. of dried quartz. The blast is now turned on for 30 to 45 minutes, when the converter is tilted to pour slag. While the slag is pouring, 5 to 6 tons of matte is introduced, and after the pouring is completed, 3 tons of quartz or siliceous ore is added. Another blow then begins. This cycle of blowing and addition of matte and siliceous flux is continued until 70 to 80 tons of finished material (blister copper) has accumulated. It means the charging of 300 to 400 tons of furnace matte and a period of 30 to 50 hours of blowing time, depending on the grade of the matte.

These converters handle large charges, work quietly with little mechanical loss at the throat; the slag is lower in silica, and cleaner than in acid converting.

*Costs in Converting.*[1]—Matte of 15 to 20 per cent. Cu is now being successfully converted in acid-lined converters at the plant of the Mammoth Copper Mining Co., Kennett, Calif., at a cost of 0.75 cents per pound of copper. In plants where a small amount of matte is converted these costs may be as high as 1 to 1.5 cents per ton. The low cost obtained at Kennett is due to the use of good lining material, and to the free addition of loose silicious ore. It was felt, that while by basic converting it might be possible to bo better work, yet for the small amount of matte treated the cost of a basic installation and the payment of a royalty would not be justified.

In this connection, basic converting in a well-conducted plant is now performed at a cost below $4 per ton.

*Upright Converters at Cananea.*[2]—Six converters, of the type developed by A. E. Wheeler the superintendent of the Great Falls plant of the Anaconda Copper Company are being installed at Cananea, Sonora, Mex. They supersede the horizontal type.

### Smelteries

*Smelting Works of the Société Minière de Bogolowsk.*[3] Richard Davey gives a description of this works and the operations.

[1] *Eng. and Min. Journ.*, XCIV, 982, XCV, 103.
[2] *Daily Min. Rec.*, Feb. 24, 1913.
[3] *Bull.* 101, *Inst. Min. and Met.*

The works treats ores from seven mines of the Bogolowsk property on the east slope of the Ural in 60° north latitude.

Some 78,000 tons, mostly of sulphide copper ores, some containing gold and silver, are produced annually, of which 40,000 from the Bogolowsk contains $SiO_2$, 27 per cent.; $Al_2O_3$, 12 per cent.; Fe, 24 per cent.; Cu, 6.0 per cent.; S, 16 per cent., and CaO and MgO, 9.5 per cent.

The ores are delivered by rail in 10-ton cars passing in double line over stalls of 500 tons capacity, where they are bedded, together with by-products from the works. The fine ore together with the flue-dust is sintered in pots by blast-roasting.

There are two water-jacketted blast-furnaces, one of 36 by 84 in. and 200 tons capacity, the other 42 by 210 in. and of 500 tons capacity; this latter being almost exclusively used as being more economical. It has 30 tuyères 3 in. diameter, and the height from tuyères to charging floor is 14 ft. 3 in. The gases pass off by a goose-neck down-take to a partitioned dust-chamber, and to a stack 200 ft. high. The blast-furnace is supplied with air under a pressure of 24 oz. per square inch from two Root blowers, one giving 20,000 cu. ft. of air per minute, the other 10,000 cu. ft.

There are two forehearths, brick-lined, of magnesite brick with an extra thick magnesite slab at the tap-hole. These forehearths are used alternately. By using ground magnesite mixed with the stopping clay the tap-hole will last several weeks and it is seldom necessary to revert to the second forehearth. The slag and matte spout is of copper, water-cooled. The slag, issuing from the forehearth, passes through a 3-ton pot, and sometimes two in series, the second pot being tapped every two or three days to draw off the matte, which has then accumulated. The slag is granulated by a flat stream of water, raised by a bucket elevator, and delivered it into cars.

To facilitate granulation the stream of slag in the outflow launder is flattened by flowing over an angle-iron set across the launder. The railway company charges 2 cents per ton for removing the slag to a dump or for ballasting. The furnace-charge is shovelled from the stalls into 2-ton charge cars, and put into the furnace through side-doors, a charge being six cars, three to the side. Coke is shovelled in separately on top of each levelled-off charge.

The furnace top is kept cold as a hot top is found to use up more coke and to increase the production of flue-dust. Some 30 per cent. of the fine (less than 1/2 in.), but the flue-dust production is only 2 d in winter, when the charge is partly frozen, 1 1/2 per cent. composed of: Ore, 75 per cent.; sintered ore and flue-dust, limestone, 2.6; foul slag, 5, and converter products,

11.4 per cent. The coke amounts to 7 per cent. of the charge, the sulphur to 10 per cent. of which 6.6 per cent. is volatilized.

The matte contains 30 to 40 per cent. copper. The slag has the composition: $SiO_2$, 38.6 per cent.; $Al_2O_3$, 12.0; FeO, 34.0; $S_2$, 0.3; Ca, 12.8; MgO, 1.5, and Cu, 0.28 per cent.

Coke costing $12.40 per ton was formerly used to the extent of 7 per cent. of the charge. This has, however, been in part substituted by a local lignite, costing 90 cents per ton, so that now the consumption is 5 per cent. coke and 5 per cent. lignite. The grade of the matte remained the same after the change of fuel. The lignite contains moisture, 15.77 per cent.; volatile conbustible, 31.81; fixed carbon, 45.49 and ash 6.47 per cent.—total, 99,54 per cent.[1]

The matte is treated in acid-lined converters, the converter-slag being returned to the furnace-forehearth where it is poured in at the entering slag-opening.

The blister copper produced would average $14.50 per ton in gold and silver. To recover this the matte is brought to white metal of 65 per cent. by the addition of three successive chargings. Blowing of this white-metal than proceeds until some blister copper is produced, when the white-metal is hastily poured out and transferred to another converter. There remains copper (copper bottoms) containing the gold and silver. This is then cast into anodes. With a little practice it is possible to make bottoms representing the desired proportion of total output of copper.

The converters run six charges without repairs, the lining consisting of 80 per cent. sand and 20 per cent. of clay. The old lining as removed is sorted into "rough," the slagged portion, and fines crushed to less than 4 mm. size. The fines are concentrated, yielding a heads which carries 35 per cent. Cu. This is briquetted with tar and returned to the converter. The tails, containing 1 per cent. Cu are reused, being mixed with other lining material.

*El Boléo Smeltery.*[2]—This plant, situated at Santa Rosalia, Lower California, was rebuilt in 1901 and 1906 and has thirteen blast-furnaces. Blast, at 12 to 14 oz. pressure, is supplied by six Connersville blowers driven by three 175-h.p. compound engines. Sea-water for the jackets is supplied by a duplex pump of 10,000 gal. per minute driven by an engine of 240 h.p. The slag is handled by electric locomotives and is poured into rough holes in the ground. After solidifying the masses are removed and dumped over the end of the breakwater, thus serving for its extension. For smelting, German coke and English coal are used, and patented coal briquettes for general fuel.

[1] C. Stutzer, Asst. mgr. Bogolowsk Works.
[2] *Min. and Sci. Press*, CIV, 700, 685.

The furnaces are 150 by 42 in. at the tuyère level. The jackets are 6 ft. 8 in. high and with 6 ft. 8 in. additional height of brick work extend to the feed-floor. There are 12 tuyères on each side of 4-in. diameters. The furnaces have crucibles from which the matte, as it settles out, is periodically tapped off. The slag flows continuously from the two ends of the furnace through 4-in. tap-holes. Exterior forehearths are not practicable owing to the rapid chilling of the acid slag used.

The furnaces are run slowly with an output of 200 to 250 tons in 24 hours. They are operated with a cool top, due in part to the slow running and in part to the fact that the charge contains 20 to 30 per cent. of moisture. The charge carries on an average 4.5 per cent. Cu The copper of the ore occurs as chalcocite and covellite. Some 12 per cent. coke is used, and it is claimed that it is more perfectly burned to carbon dioxide than is usual in American copper smelting practice. To smelt with the greatest economy a minimum amount of fluxing material is employed with the production of a slag of this composition: $SiO_2$, 52 per cent.; $Al_2O_3$, 18; FeO, 6 to 8; MnO, 4 to 6, and CaO, 10 to 12 per cent. The slag is unusually siliceous and evidently the alumina is here acting as a base but the manganese is a factor in producing fluidity. Because of the rapid separation of the matte in an inside crucible, and of its high tenor in copper, the slag contains always more than 0.5 Cu. The matte carries 60 to 65 per cent. Cu. A premium of £2 per ton is paid for matte of this grade as compared with a matte of the ordinary shipping grade of 40 per cent. It is desirable for mixing with the lower grade mattes when converting. The matte is shipped to Europe for bessemerizing, it having been found more profitable to do so than to treat it locally.

*The Great Cobar Smeltery.*[1]—This is a four-furnace plant of 2000 tons nominal capacity; costing $750,000 to erect. The furnace building is of steel, with corrugated iron roof but with open sides. Ore is taken from storage bins of 12,000 tons capacity in hopper-bottom cars hauled by electric locomotives. The charging is done from V-shaped side-dumping cars of 34 and 44 cu. ft. capacity, on 36-in.-gage tracks running on either side of the furnaces at the charge-floor level.

There are four blast-furnaces, 240 by 56 in., set end to end with settlers hearths between and at the ends, giving each furnace alternative at either end. There are two tiers of water-jackets 4 by 10 ft., furnace has 40 tuyères with a 34-in. bustle pipe. The furnaces from ground to tapping floor, 26.5 ft. from tapping to charging re is a continuous discharge from the furnace to forehearths, ft. The slag is received in slag-pots of 200 and 280 cu. ft.

*Press*, CV, 234; Stevens' "Copper Handbook," X, 884.

(20 to 28 tons). Blast is supplied by four Morley engines coupled to two Connelsville blowers of 36,000 cu. ft. of air at 42 oz. pressure per square inch.

The furnace charge is approximately 80 per cent. of Great Cobar ore with silicious ore from other mines of the company. About 9 per cent. of coke is used. Furnace-slag is not returned, but converter slag is used at the blast-furnaces.

The reverberatory department has 14 roasting furnaces and four reverberatories. Each reverberatory is connected to a flue common to two furnaces. This leads to the main flue 6 by 7 ft. in section by 1400 ft. long terminating in a stack 129 ft. high. The bottom of this flue is provided with steel hoppers with draw-gates, discharging into steel cars running on a track beneath. (Better practice would appear to be to substitute for this long flue a capacious dust-chamber where the dust can properly settle.) The reverberatory matte carries about 35 per cent. Cu.

The converter department has two 40-ton electric cranes of 50-ft. span. Three stands of converters are electrically operated. The shells are 84 by 126 in. of the horizontal or barrel type. Siliceous gold ores from the Cobar gold mine, averaging 1.25 to 1.30 per cent. Cu and 0.50 to 0.5502 oz. Au per ton, are used for lining. The converters are supplied by a Walker Bros. compressor, giving 9000 cu. ft. of free air per minute. The converter bars are shipped for refining to the Lithgow works of the company 370 miles distant.

The power-plant contains six Babcock & Wilcox boilers of 3580 sq. ft. of heating surface, fitted with super heaters. Three Browett-Lindley triple-expansion engines of 250 h.p. each are direct-connected to Siemens electric generators for general power purposes.

*The Copperhill Smeltery of the Tennessee Copper Co.*[1]—The ore has the composition, Cu, 2 to 2.5 per cent.; Fe, 31 to 37; S, 20 to 30; $SiO_2$, 10 to 25; CaO, 6; MgO, 2; Zn, 2 per cent. being a heavy sulphide ore.

There are seven blast-furnaces, three 180 by 56 in., three 270 by 56 in. and one 44 by 270 in. The height of the charge is from 10 to 12 ft. The smaller furnaces have a capacity of 375 to 400 tons daily, using 19,000 cu. ft. of air per minute at a pressure of 50 oz. per square inch. The larger furnaces are of 500 to 600 tons capacity. Many trials have been made, using wide and narrow jackets. Curved end-jackets have been employed with a view of lessening the formation of crusts at the corners, but, while barring down was easier, the tendency to crusting has not lessened, and these jackets have been given up. A slotted tuyère is employed 12 in. by 4 in., replacing two round ones of 3 1/4 in. diameter.

[1] "Modern Copper Smelting," Levy, p. 184.

Fig. 12 is a side and back view. There are three punching holes, 1 1/2 in. dia., and this facilitates punching and keeping the tuyères open. This type of tuyères has proved very successful. Charging is done using side-dumping V-shaped cars, and great care is taken in the handling and distribution of charges.

Furnace-operation consists in smelting the ore pyritically for a 9 to 10 per cent. matte. The products pass through a 16-ft. settler lined with siliceous copper ore. The matte is tapped into ladles which are emptied into beds of flue-dust. Alternate layers of matte and dust are thus incorporated, and yield a porous material, well suited to the concentrating pyrite smelting which follows. This concentration is conducted in a furnace narrowed to 44 in. The furnace runs fast, smelting sometimes over 800 tons daily. It is driven hard as long as it smelts rapidly. When it slows down, it is tapped out and started afresh. A saving of 0.1 per cent. of copper is obtained by addition of limestone as compared with slags made without such addition.

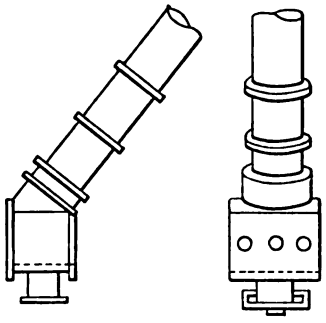

Fig. 12.

The matte is bessemerized.

*The Copper, Queen Smeltery.*[1]—This works is situated at Douglas, Arizona, and is located on a site having a slope of but 1 1/4 degrees from the receiving-end toward the furnaces. Thus it is possible to run the loaded charge-trains from the ore-bins to the furnaces by an easy grade, a distance of 2000 ft. The plant occupies a space 2000 by 5000 ft. The receiving and distributing system comprises 25 miles of standard-gage track. The main building, 150 by 900 ft., contains the ten blast-furnaces and eight converters arranged in parallel lines on opposite sides of a 60-ft. crane-way. At the end of the building is the converter relining plant.

The ores, whether from the Copper Queen mines or purchased from other mining companies, are bedded to form a smelting mixture in pits having walls of stone, each pit being 800 ft. long, 38 ft wide and 11 ft. deep. To send it to the furnaces the ore is reclaimed and loaded into cars by steam-shovel, then hauled to the furnaces by electric locomotives. On the way to the furnace the charge-trains take flux and fuel, stored in separate bins. The ore is, however, not weighed but measured, while the flux and fuel are weighed.

The works has a calcining plant of six 18-ft. McDougal roasters, and a reverberatory melting plant of two furnaces, each of 91 by 19 1/2 ft.

[1] *Bull. Inst. Min. and Met.*, No. 101, 34, 36.

hearth-dimensions. The matte from these melting furnaces is run into ladles handled by the same crane which takes care of the blast-furnace matte.

The converting plant, formerly acid-lined, has been changed to the use of a basic lining as being more economical, and making it possible to use ores low in silica. It is to be noted that the present barrel-type converters are being replaced by upright converters, 12 ft. diameter.

It is difficult to treat the ores in blast-furnaces due to their extreme fineness and because of their high alumina content. The disintegration of the contained pyrite, and the clay, and the use of much fine concentrates results in much flue-dust. Part of this dust, entirely escaping, had entailed a loss additional to that in the slag.

To determine the dust-loss, smoke was drawn off near the top of the main stack through an 8-in. pipe by means of a suction fan, the velocity of gases in the pipe being the same as in the stack. The discharge of the fan was filtered through woolen bags of the closest weave in order to arrest the finest dust of the smoke. An experiment showed that 90 per cent. of the dust thus collected would pass through a 200-mesh screen. These filtering experiments were conducted under varying conditions of draft and furnaces, recovering in each experiment some 9 tons of dust. The percentage recovered varied from 0.06 to 0.16 per cent., the larger amount occurring with the larger number of furnaces in operation. This dust carried approximately Cu, 9 per cent.; Pb, 8; Zn, 5 per cent. Since the escaping smoke (gases) was in excess of 1,000,000 cu. ft. per minute, bag-filtration was not considered, and the flue-dust was settled out by passing the smoke through a settling-chamber. It was found at a velocity of 150 ft. per minute and less, the very fine dust would settle in a short distance and with wire screens spaced at 3-ft. intervals equally good settling was obtained at 300 ft. per minute and less, so this latter installation was adopted. Experiments similar to the above were tried with converter smoke. The percentage here recovered varied from 0.015 to 0.035 per cent.

The new dust-chambers have a steel frame with hollow tile for floors, walls and roof. The roof is suspended from trusses exterior to the chamber. The wire-screens are so arranged that there are at least ten obstructions to the passage of the gases.

The sintering of flue-dust by mixing it with molten converter slag[1] has been tried out, with a view to putting the slag in proper shape for the blast-furnaces and to put the flue-dust in fixed lump form. For the purpose a large steel truncated cone set with the axis horizontal is used. This is lined with cast-iron and has riding rings supported on rollers as

[1] MINERAL INDUSTRY, XX, 218.

in a horizontal converter. The cone is driven by chain and sprocket, though a gear-and-pinion drive is favored. The converter-slag, poured from a ladle, and the flue-dust from a pipe leading from a storage tank, are delivered together into the small end of the cone which revolves five times per minute. The action rolls the slag and the dust together, making a porous lumpy material well suited to blast-furnace work. The operator, facing the discharge end of the machine, can regulate the tilting of the slag-ladle, the dust-supply and the revolutions of the machine.

*The Granby Smeltery.*[1]—George M. Lee gives us valuable information supplementing that in MINERAL INDUSTRY, XVI, 352; XVII, 268; XVIII, 207; XIX, 206.

The ore now carries $SiO_2$, 35 per cent.; Fe, 13; CaO, 17; MgO, and $Al_2O_3$ 8 per cent.; silica and magnesia having decreased since 1909. The iron is present as silicate, uncombined oxide and sulphide, the lime and magnesia as carbonates, the copper as chalcopyrite. The ore carries

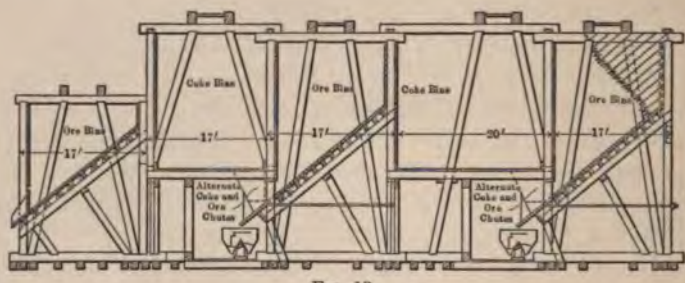


FIG. 13.

little sulphur, is self-fluxing, and hence is cheaply smelted. Since organization 7,299,911 tons of ore have been treated, and it is estimated that of actual ore there is 6,500,000 tons in the mine.

Fig. 13 is a transverse section of the ore and coke-bins. The latter bins have flat bottoms to increase capacity. Beneath the bins are the longitudinal tracks for the charge-cars. It will be noticed that on two of the tracks a charge-train can receive both ore and coke.

For Granby ores a sample is taken at random each week from each of the three crushers at the mine. This gives three 70-ton samples, about 1 per cent. of the ore mined. It is delivered to one of the ore bins. From it the ore, drawn into tram-cars, goes to the gyratory crusher at the mpling mill, is crushed to 3-in. size and passed through the mill, being by one-fifth three times, crushing after each cut and making a sam- 1/125 of the lot equal to 1.68 tons. This sample, now of 1/4 in.

[1] *and Chem. Eng.*, X, 147.

size, is quartered by hand until reduced to 20 lb., then finished for the laboratory.

In the case of custom ores the one-fifth sample arising from the first cut is saved in a bin, while the rejected or principal portion passes through the sampling machinery, the automatic samplers remaining idle. The object of this is to crush all the ore sufficiently fine for converter-lining. The one-fifth sample is then put through the mill.

Fig. 14 shows in elevations and sections the construction of the furnaces, and in the transverse elevation and section the charge-car in posi-

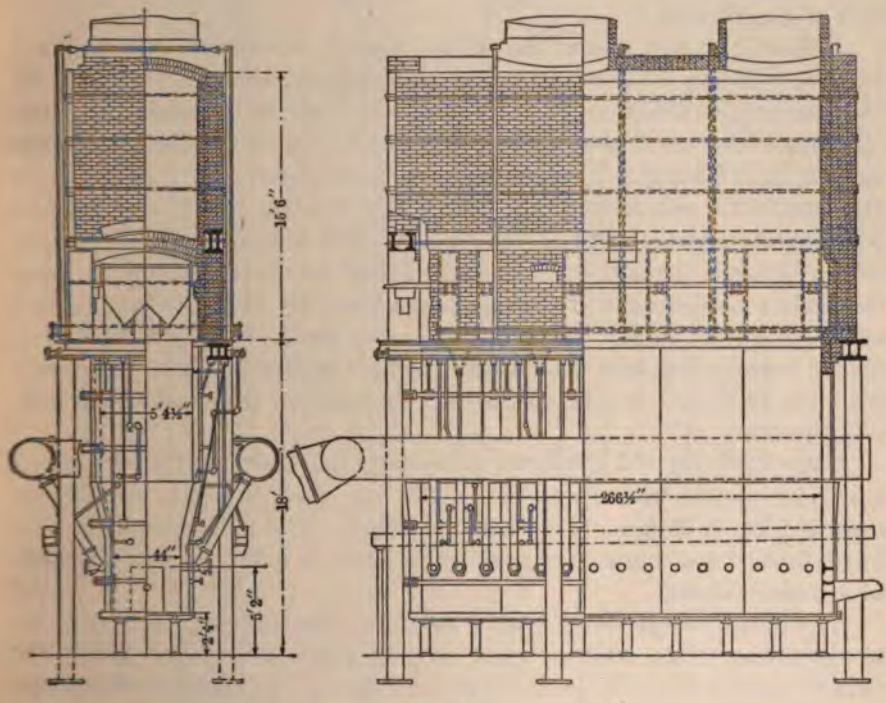


FIG. 14.

tion in the furnace. The foundations are of concrete. The jackets are of steel 7/16 in. thick on the inside and 3/8 in. on the outside. They extend to the charge-floor in two sections, respectively 7 ft. 6 in. high with a 3 7/8-in. water-space and 7 ft. 9 in. high with a 3 5/16-in. water-space. Water enters the upper tier of jackets at the bottom and leaves at the top, then circulates in the same way in the lower tier. Thus, while the upper jackets are well cooled, the lower ones, fed with warmer water, are not so chilled. The furnace-tops are of red brick lined inside with

fire brick, and bound outside with 60-lb. rails. The entrance at one end of the furnace for the charge-car is always open. The eight furnaces together use 2000 gal. of water per minute equal to 3 gal. per square foot of hearth area. Each furnace takes 25,000 cu. ft. of air per minute at a pressure of 24 to 28 oz. per square inch.

The three cars of the train hold in all 10 tons, and are handled by a 30-ton electric locomotive. Coke and ore are separately charged, a complete charge being put in every 15 to 20 minutes. The capacity per furnace is 300 to 600 tons of ore, and a maximum for all the furnaces of 3000 tons in 24 hours has been reached, equal to 7 3/4 tons per square foot of hearth-area.

Referring to the plan of the works, Fig. 15, at the rear of the blast-furnace building is shown a steel dust-chamber, which is 15 by 13 ft. in cross-section, 315 ft. long, and is raised 21 ft. above the feed-floor level. The bottom of the flue consists of pyramidal hoppers. Flue-dust after settling in the hoppers is discharged into a drag-conveyor. This carries the dust to the briquetting mill, where it is moistened and briquetted in a White briquetting-machine of a capacity of 50 tons daily. (A reaction, set up between the added water and the iron sulphate in the dust, soon results in a hardening of the briquettes so that they are quite firm for use in 24 hours—L. S. A.). The dust-chamber connects with a brick flue 450 ft. long leading to a stack 13 ft. diameter by 150 ft. high. The dust from the brick flue is cleaned up with shovels and trammed to the briquetting mill.

Since 1908 the old converter equipment has been replaced by three converter stands with shells 84 by 126 in. Each stand is electrically operated by a 35-h.p. direct-current motor. The converter-shells are lined first with a course of chrome brick, then by a 2-ft. layer of ganister for converter lining.

The matte charge varies from 3 to 9 tons, depending on the condition of the lining. The blister copper, of 98.5 per cent., is cast in 200-lb. bars in moulds 24 by 33 in. mounted in rows on 16 ft. trucks which run past the converters, the trucks being moved by cables and an electrically-driven drum. The converter slag, 100 tons daily, cast in an Edwards moulding-machine, is cooled by water, and falling from the end of the machine into cars, breaks, so that it is ready for charging to the blast-furnace. This slag contains approximately $SiO_2$, 30 to 34; FeO, 33; Cu, 1 to 1.5 per cent. The converters are still [illegible] to the profits derived from the silicious ore used.

For the year ending June 30, 1912, there were 13,753 tons of siliceous converter slag used in relining 1573.5 converter shells being [illegible] each lining. For the linings 1500 tons of coke were

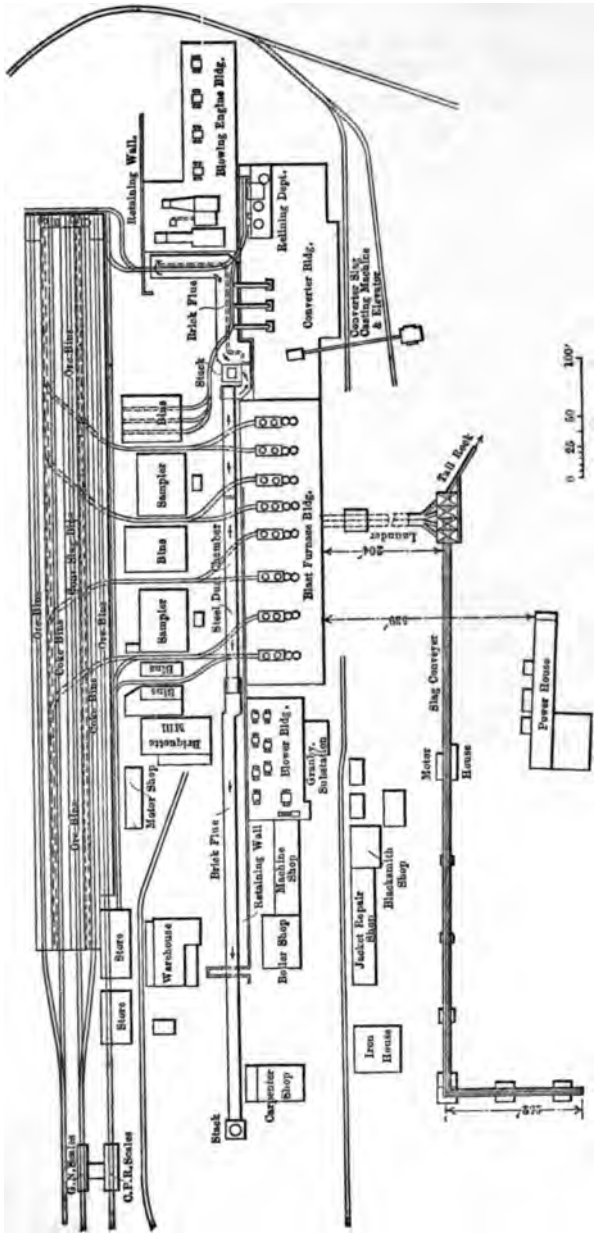
Blowing Engine Bldg.
Retaining Wall
Refining Dept.
Converter Bldg.
Brick Flue
Stack
Ore Bins
Coke Bins
Floor Slag Bins
Sampler
Bins
Steel Dust Chamber
Blast Furnace Bldg.
Ball Rock
Launder
Slag Conveyor
Power House
Motor House
Blower Bldg.
Granulated Slag
Retaining Wall
Machine Shop
Boiler Shop
Jacket Repair Shop
Blacksmith Shop
Iron House
Warehouse
Stores
Carpenter Shop
Motor Shop
Briquettes
G.N. Scales
G.F.R. Scales
0 25 50 100'

FIG. 15.

and or to dry out each lining about one ton of coke. In the same year the converters handled 31,868 tons of 37.5 per cent. matte and produced 2,754,899 lb. of blister copper.

In the steel "blowing-engine building" (see plan, Fig. 15) are four No. 10 blowers. There are three blowing-engines, which furnish air to the converters at 12 lb. pressure per square inch. One engine is a Nordberg with 36 by 36-in. cylinders belt-driven by a motor of 200 h.p.; the second is an Allis-Chalmers duplex blowing-engine, 34 by 34 by 36 in., delivering 5000 cu. ft. of air per minute, belt-driven by a 300-h.p. motor; and the third is a Nordberg 40 by 42-in., rope-driven by a 500-h.p. motor. The building also houses a compressor for furnishing air at 80 lb. pressure for the relining department, and a motor-generator set for furnishing a current at 250 volts to the electric locomotives and the cranes.

In the steel blower-building (recently remodelled) are three No. 7 and four No. 8 Connersville blowers, having an average output of 13,500 cu. ft. of air per minute. Each of these is driven by a 100-h.p. motor. There is also one No. 10 blower of 30,000 cu. ft. capacity driven by two 150-h.p. motors.

The slag was, until recently, removed in slag-pots and dumped at the edge of the waste dump. Because of the increasing expense of doing this it is now granulated and conveyed to waste as follows:

The slag, flowing from the settlers of the eight furnaces, is granulated by a jet of water from a flattened nozzle 1/2 by 1 1/4 in., and falls into concrete receiving-troughs 7 ft. long by 12 in. wide having a grade of 7/8 in. per foot, and lined with cast-iron plates 1 in. thick. These troughs connect to wooden launders, which carry the granulated slag to the main launders, these delivering to slag-receiving bins or hoppers placed 204 ft. directly in front of the blast-furnace building. The excess water runs away by a tail-race, see Fig. 15.

The four wooden receiving bins have a united capacity of 200 tons of slag. From the bins the slag feeds upon a 24-in. inclined belt-elevator at 18 degrees and this upon another in series until the slag is raised 115 ft. above the present slag-dump level at a distance of 580 ft. horizontally. It here discharges upon a horizontal 24-in. belt-conveyor 252 ft. long. An automatic tripper distributes the granulated slag the length of the belt. When the dump thus formed reaches the level of the horizontal belt, this is moved laterally and the inclined belt extended.

*Mungana Smeltery.*[1] —This works treats copper sulphides from mines in the Chillagoe district, North Queensland, Australia. The ore, assorted into coarse and fine, is stored in bins of 1500 tons for ore and 500 and 700 tons for coke. The ore is drawn up an incline to above the

[1] Queensland Government *Min. Journ.*, Sept. 14, 1912.

bins. The charge materials are received in ore-cars running beneath the bins, which deliver to two double-cage elevators. These raise the materials 35 ft. to a landing stage, and from here by another track to the sinter plant, to the converter-lining bins, and to the blast-furnace.

The fine sulphide ore and flue-dust is sintered on a 42-in. Dwight-Lloyd sintering-machine, electrically operated. The sintered and other charge material is weighed into side-discharge charge-cars at the ground level, the cars then being elevated to the blast-furnace charge-floor.

There are two furnaces, respectively of 42 by 84 in., and 42 by 168 in., the latter only being in operation. It is water-jacketted to the feed-floor, has a closed top, and a goose-neck down-take to a dust-chamber, and to a stack 170 ft. high by 8 ft. diameter. The furnace has an internal sump, and a forehearth 12 ft. diameter. The slag is removed in double slag-pots to the dump on a 36-in. gage track laid with 42-lb. rails. Air for the blast-furnaces is furnished by two high-speed air-compressors, each capable of delivering 6500 cu. ft. of free air per minute at 5 lb. pressure per square inch. The matte, which runs as high as 55 to 65 per cent. Cu, is tapped off periodically into 9-ton sectional steel ladles.

In the converter building are two stands, the converter shells being 90 in. diameter by 126 in. long. There are sliding hoods to take the converter gases, delivering to a steel stack 90 ft. high by 5 ft. diameter. The converters, as well as the traveling crane, are electrically operated. The crane has a main hoist of 40 tons and an auxiliary hoist of 5 tons capacity, a longitudinal travel of 139 ft. and a cross travel of 35 ft. Converter blast is supplied by a Walker's slow-speed air-compressor, rope-driven from a line-shaft to deliver 3800 cu. ft. of free air per minute at 15 lb. per square inch.

Gas for power is developed from three Dowson pressure gas-plants of 500 h.p. each; each unit being capable of independent running. Power is generated by three Kynoch gas engines of 320 h.p. each, and two Hornsbey gas engines of 200 h.p. The Kynoch engines are of the tandem type and run at 160 revolutions, the Hornsbey engines at 200 revolutions per minute.

*The Isabella Smeltery, Ducktown, Tenn.*[1] —The works comprise two furnaces, 204 by 40 in. at the tuyères, and 9 ft. high above the tuyères, having a joint capacity of 500 to 600 tons daily. Air, at 20 to 30 oz. pressure per square inch, is supplied through 3-in. tuyères. The first smelting yields a 20 per cent. matte from a 2 per cent. ore, while reconcentration results in a converter-grade matte of 50 per cent. Cu. At the first smelting 5 per cent. of coke is used, for reconcentration 3.5 per cent. Feeding is done by the Freeland charging apparatus. The charge

[1] "Modern Copper Smelting," Levy, 188.

is carried at 6 to 8 ft. above the tuyères and is evenly red-hot all through. The slags carry $SiO_2$, 35 to 36 per cent.; Fe, 38.8; CaO 8 per cent. The escaping gases contain $SO_2$, 3.5 per cent.; $CO_2$, 3.5; O, 8 per cent.; $SO_3$, trace. They are used for making sulphuric acid. The annual output of the plant is 3000 tons of copper.

*Copper Works at the Kyshtim Estates.*[1]—E. J. Carlyle, former manager of the Karabash plant, gives a first-hand description of the work as presented in the description following: The headquarters of the Kyshtim Corporation, Ltd., are at Kyshtim, Perm, in the Southern Urals on the government railway. Twenty-five miles to the south lies the Soimonosk Valley, where are the principal mines of the company, and the Karabash Smeltery, connected to Kyshtim by a railway of 36-in. gage.

An average of the ore, as supplied by the various mines, is as follows: Cu, 3 to 4 per cent.; S, 40.8; $SiO_2$, 12; Fe, 34.1; CaO and alkaline earths, 3 to 6 per cent., together with Au 0.1 oz. and Ag 1.0 oz. per ton.

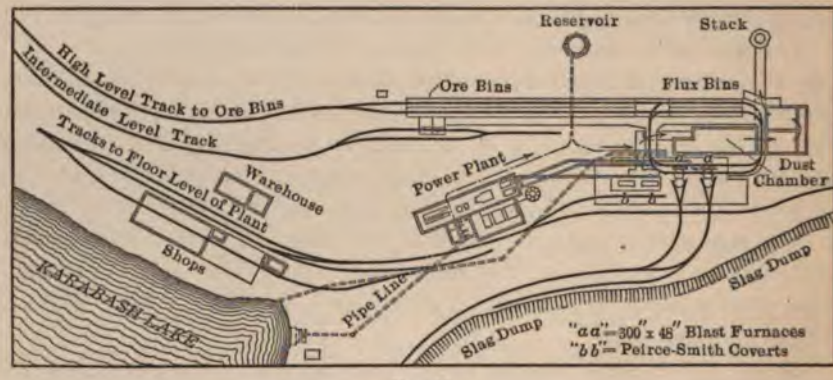


FIG. 16.

Fig. 16 is a plan of the works at Karabash. The site is chosen on a hillside at a point midway between the principal ore-bodies. The railway from the mines enters the works by a high-level track to the ore bins of 6000 tons capacity. A spur at an intermediate level handles the ore from the sampling mill, and delivers coal to the power-plant, while a second spur, at the ground-floor level of the plant, serves the shops and removes the finished products. The ore arrives from the mines in 10-ton steel cars. Each tenth car in rotation from each mine is dumped into receiving bin of the sampling-mill. The rejected ore is withdrawn standing on the intermediate track. The ore-bins have flat ıe bottoms having slots 30 in. wide. These slots are covered

1. *Journ.*, XCIII, 1231; *Gorny Journ.*, 1912; *Min. and Sci. Press*, CIV. 891; *Intl. m.* III, 113.

by loose 4-in. planks. Movable chutes, having arc-gates, are suspended beneath the slots. To withdraw ore, a chute is placed beneath the toe of the sloping talus of ore in the bin above, then two or three planks are removed, permitting the ore to run into the chute. As the ore is removed other planks are taken up, thus ensuring a sufficient supply. The chute is occasionally moved. The slots also provide a convenient opening when it is desired to clean out the bin. The chutes deliver to the charge-cars.

Beneath the ore-bin chute, and beneath the flux-bins at the charge-floor level, are laid 24 in.-gage tracks of 54-lb. rails leading to the blast-furnaces. There are three charge-trains, each of four side-dump steel cars, each car of 4000 lb. capacity. These trains are moved by 3-ton Westinghouse electric motors equipped with 18 h.p., 220 volt, direct-current motors.

There are two blast-furnaces, each of 500 to 600 tons capacity, measuring 48 by 300 in. at the tuyères, and 22 ft. 8 in. from the crucible plate to the feed-floor. They are jacketted to the apron plates.

The air is delivered through a 24-in. bustle-pipe to 52 tuyères, 26 per side, but, since the four over the tap jackets are seldom used, air enters by 48 of the tuyères only. There are two turbo-blowers installed by Parsons & Co., Newcastle on Tyne, Eng., who guarantees their performance as follows:

| Air pressure. | Free air per min. | Steam, lb. per hr. | Revs. per min. |
|---|---|---|---|
| 60 oz. | 30,000 cu. ft. | 10,700 lb. | 3400 |
| 50 oz. | 24,700 cu. ft. | 7,770 lb. | 3000 |
| 40 oz. | 22,700 cu. ft. | 6,100 lb. | 2700 |

It was not found possible to force 30,000 cu. ft. per minute at 60 oz. pressure through the deep charge used, and to keep the pressure down to the preferred amount of 40 oz., the blower had to be run much below full speed. This led to running both furnaces with one blower, the other being held in reserve.

Each furnace has two bronze tap-jackets placed at the center of each side. At the front side is provided a water-jacketted slag-spout, Fig. 17, which is lined with magnesite brick. At its front is attached a water-cooled nose-piece of blister copper. As shown in the figure, it does not cover the entire front opening of the spout proper, so that a space is left beneath the nose-piece, and this is stopped with clay. In case it is desired to quickly empty the hearth, a strong thrust with a bar is sufficient to break through the clay-stopping. The tap-jacket at the opposite and rear side, is used when blowing in, the colder slag, produced during the

first 20 or 30 minutes, being permitted to escape at this opening rather than into the settler. Again, the jacket may be tapped in case the front tap-jacket is lost, as the blast can still be kept on, and the slag run out at the back while the breast is being drilled.

Each furnace has a 15-ft. settler, formerly lined with refractory brick. Recent practice has resulted in the adoption of soapstone, quarried near by, and cut into shapes suitable for lining. Each settler is provided with two spouts on opposite sides of the forward end. The slag is received into 4-ton cars, each having two cast-iron elliptical bowls mounted on suitable trucks. Two such cars are placed on each side of the settler.

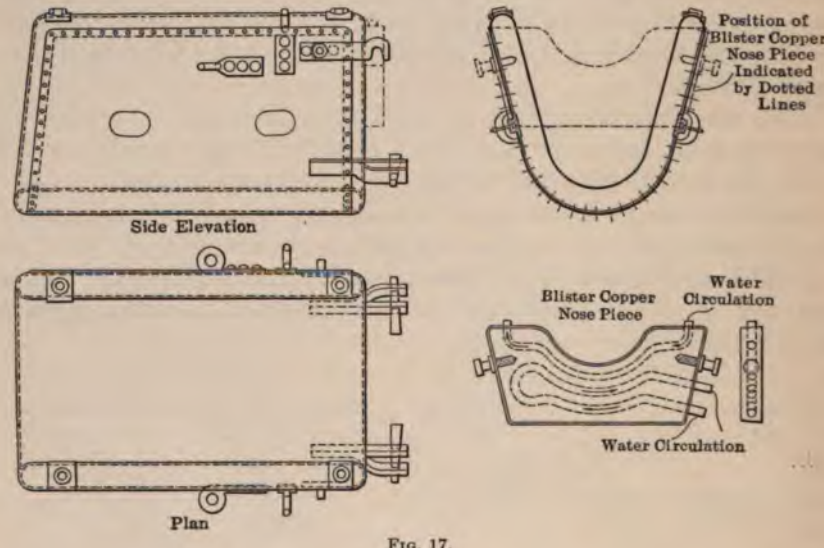


FIG. 17.

When two cars have been filled, the flow is diverted into the other two, the first cars then being removed to the dump by means of an elertric locomotive. In case of accident to the locomotive, there is a launder beside each settler, through which the slag can be drawn, granulated by jacket water, and run to waste.

The charging is effected as follows: A flux-train of four cars containing quartz, lime rock, and waste-slag is brought to, say the east side of a furnace, and dumped through the four doors on that side. Then two four-car trains are brought in, one to each side. These three trains constitute a charge, having a total weight of 50,000 lb. For the next charge the fluxes are dumped on the west side and so alternately. The coke is shoveled in at end doors just before the fluxes are dumped. It constitutes 1.25 per cent. of the charge.

During a recent month a charge was made up as follows: Ore, 28,800 lb.; quartz, 6350 lb.; limerock, 1900 lb.; sweepings, 1300 lb.; matte, 2250 lb.; a total of 40,600 lb. of ore and fluxes, to which was added 500 lb. of coke, or 1.25 per cent. of the charge. The slag for the month averaged $SiO_2$, 31.9 per cent.; FeO, 53.1.; CaO, 4.4; S, 1.5; $Al_2O_3$, 2 and CuO, 0.3 to 0.5 per cent. Other things being equal, the slag is slightly cleaner with a high matte-fall.

The quantity of mixture for the month of July 1911, was 37,000 tons containing 27,500 tons of ore. There was produced 2460 tons of matte, being a matte-fall of 6.6 per cent., 2900 tons of flue-dust or 7.8 per cent., and 27,500 tons of slag or 62.9 per cent. of the charge mixture. The matte assayed Cu, 26.53; Fe, 41.4; and S, 25.1 per cent. The charge mixture carried nearly 30 per cent. of sulphur, of which 5.63 per cent. passed to the matte; 4.38 into the slag and 1.76 per cent. into the flue-dust, so that 88.23 per cent. must have been volatilized. The quartz used in the converters carries 92 to 96 per cent. $SiO_2$, the limestone 53 to 55 per cent. CaO.

The ore being pyrites, as well as soft and friable there is a large production of flue-dust. Even though the ore is now screened, the coarse ore going to the blast-furnaces, the dust recovered never falls below 10 per cent. of the ore charged. The dust from the furnaces goes by downtakes, 6 ft. diameter, to the dust-chamber of 945 sq. ft. cross-section by 100 ft. long (as shown in the plan), and to two dust-chambers in series, each of 1610 sq. ft. cross-section by 60 ft. long. After leaving the first chamber the gases pass through four walls in which midway between the roof and floor are openings spaced to evenly distribute the gases and to diminish their velocity. The floors of the chambers have flat cast-iron arches pierced with six inch openings in which rest conical valves. These valves have spindles and handles, the trammers on the track below forcing these upward, permitting the dust to flow into cars set beneath.

From the last chamber the gases proceed through a flue 12 by 121/2 ft. up a slope of 31 degrees to a stack 16 ft. diameter by 185 ft. high, the top of the stack being 241 ft. above the blast-furnace charge-floor.

The flue-dust is sent away to Kyshtim for treatment, and the low-grade matte resulting, is returned to the Karabash plant, when it is put through the blast-furnaces.

At the Karabash works, Fig. 16, there are two Pierce-Smith basic converters, views of which are shown in Fig. 18, 25 ft. 10 in. long, 10 ft. diameter and lined with magnesite brick.[1] For feeding quartz a special opening was cut close to the central riding ring. When the blast is on this opening is closed with a heavy cover. After the converter has been

[1] Mineral Industry, XVIII, 199; *Eng. and Min. Journ.*, LXXXIX, 563, and U. S. Patent 942, 346.

skimmed and the matte poured in, the quartz is fed through a chute on the furnace charge-floor level as shown at the front elevation, Fig. 18. This saves time, as the quartz can be charged while the crane is still busy with the matte-ladle. Another opening at the spout level, side elevation Fig. 18, enables fettling to be executed around the tuyères.

At first the plan of treating 20 per cent. matte was followed, but it soon became apparent that this resulted in a rapid deterioration of the lining. Despite the effort to keep the heat down by the addition of scrap

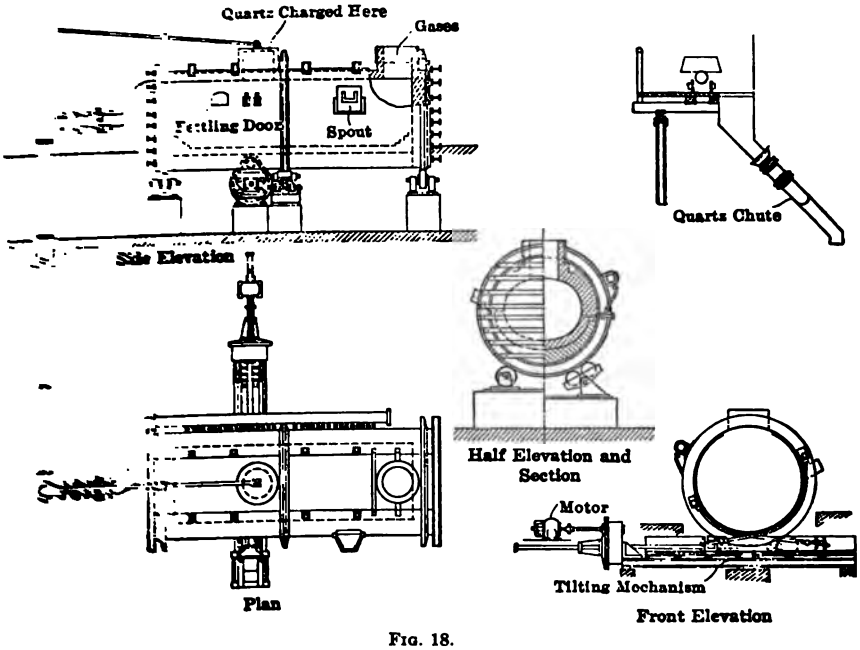


FIG. 18.

quartz, the slags would frequently fall to 18 to 20 per cent. silica, and as the temperature of formation of these slags, the bricks at the tuyère-line were rapidly destroyed by the abrasive action of the bath. In a few days these bricks would be worn back nearly to the lining, and the water-pipes would be burned away. The campaign could be prolonged by ramming in of a fettling of silicate of soda (water-glass) and sand, but this was but temporary, and relining soon became necessary. Eventually, screened ore only was used at the blast-furnaces, which not only improved the output to full capacity, but enabled the matte of 30 per cent. Cu, and from this time the rapid corrosion of the linings ceased. The use of the low-grade matte produced at the converters aids in raising the grade of the blast-furnace matte and

there is now no difficulty in keeping the silica in the converter slag to 25 per cent. or higher.

Besides increasing the life of the linings through the use of higher-grade matte, there is another advantage gained: Since air at 15 lb. pressure is more expensive than air at 40 to 50 oz. pressure it should be better to oxidize the slag in the blast-furnace rather than in the converter. The costs for air in converting 20 per cent. matte are but half of that for matte of 16 per cent., whereas the difference in the blast-furnace should be insignificant.

In operating the converter, when the copper of a "blow" has been poured, the converter is fettled with magnesite mixture. Four to six 5-ton ladles of matte are then charged, and quartz enough to produce a good slag. When this has formed, and has been poured, another ladle of matte and more quartz is put in, and so successively, the matte being gradually concentrated, until there is a sufficiently large bath of white-metal to finish. The blow having been finished, the blister copper is transferred by 5-ton ladles to an endless conveyor casting-machine. By tilting the conveyor by the auxiliary hook, the copper can be poured into the mould at such a rate that it is cool enough to fall out at the delivery end of the machine. (This is commonly aided by the use of cooling water.) The bars are trimmed, weighed and shipped to the refinery at Kyshtim.

In July, 1911, 2012 tons of matte of 26.5 per cent. were converted and there were 438.5 tons or 877,000 lb. of blister copper of 99 per cent. Cu produced.

*Upper Kyshtim Plant.*—Fine ore, and flue-dust from the Karabash plant, is treated in Siemens-Martin regenerative-furnaces. The first matte yielded by them is concentrated in small blast-furnaces, and the concentrated matte bessemerized to blister in small converters. At this works have accumulated thousands of tons of fine ore and flue-dust.

The hearth of the regenerative furnace is 35 ft. long between the ports and 15 ft. wide. The furnace is heated with producer gas made from pine wood and is scrubbed before going to the furnace to remove moisture and tar. The analysis of the gas is $CO_2$, 7.47 per cent.; CO, 26.22; H, 8.3; $CH_4$, 5.86; and $C_2H_4$, 0.79 per cent. The stack gases averaged $CO_2$, 12.2 per cent.; O, 6.3; N, 71.5 per cent., and had a temperature of 385° C. The pressure at the reversing-valve was 0.125 in. and at the stack 1.0 in. water. The gas entered the regenerator at 68° C. The average furnace temperature was 1600° C., of the burning gases escaping at the ports 2000° C., and when entering the checkers 1300° C.

The charge was mainly flue-dust, with green ore constituting 90 per cent. of the charge, and the rest was siliceous oxidized copper ore. The

average assay of the charge was 3.1 per cent. Cu. From January to September, 1910, the furnace was in operation 166 days, putting through 10,690 tons or 64 tons daily, and using 3417 cords of pine wood, or 0.32 cord per ton of charge smelted. Wood at Kyshtim costs but $1.05 per cord delivered, so that we may compete the fuel-cost at 33.6 cents per ton of 2000 lb. In the period there was yielded 3326 tons of 8.5 per cent. matte, a matte-fall of about 30 per cent.

An average assay of the flue-dust shows $SiO_2$, 8.9 per cent.; Fe, 48.9; Cu, 3.3; and S, 10.0 per cent. The raw fine ore used with the flue-dust contains $SiO_2$, 2.1 per cent.; Fe, 38.5; CaO, 0.5; S, 47.0 and Cu, 3.2 per cent.

*The Mammoth Copper Mining Co.*[1]—To the description[2] we add certain details given by C. A. Tupper. Formerly it was found possible to operate, using favorable ores, and as little as 1 per cent. of coke, but with more silica now on the charge 4 per cent. is used, the output per furnace being 425 tons daily.

In charging, the ore is drawn from the ore-bins into side-dumping cars, which dump both coke and charge into the furnace on its long sides. The settlers are now 16 ft. diameter, and the flow from them is taken away in 5-ton slag-cars.

Converting is done at 13 lb. pressure. The converters are served by two 50-ton electric cranes, 50 ft. span, each crane having two 15-ton auxiliary hoists. From a ladleful of slag the thinner portion is poured into one of the blast-furnace settlers, the remainder, about 20 per cent., being poured into one of the converters. The converters are yet acid-lined, but much silicious ore is used in them, so that a lining will last for a production of 20 tons of blister, even when producing 20 per cent. copper matte.

The bag-house, described in MINERAL INDUSTRY, XX, 223, yields 25 tons of fume daily, consisting mostly of zinc oxide and sulphate, but carrying considerable silver, some gold, a little lead and a trace of copper.

For various uses the motor sizes are: for blowing engine 750 h.p., for the seven cycloidal blowers each 225 h.p., for two Socorro fans each 400 h.p., for two centrifugal pumps each 30 h.p., for two 50-ton cranes 75 h.p. each, and for two auxiliary hoists 15 h.p. each, besides motors for various small machines.

[illegible] is brought under sufficient head to the plant from a mountain [illegible]es distant. Two centrifugal pumps are in reserve to [illegible]tream below the works.

[illegible] *Smeltery*[3] is owned by the Mason Valley Mines

[illegible], 337.
2.

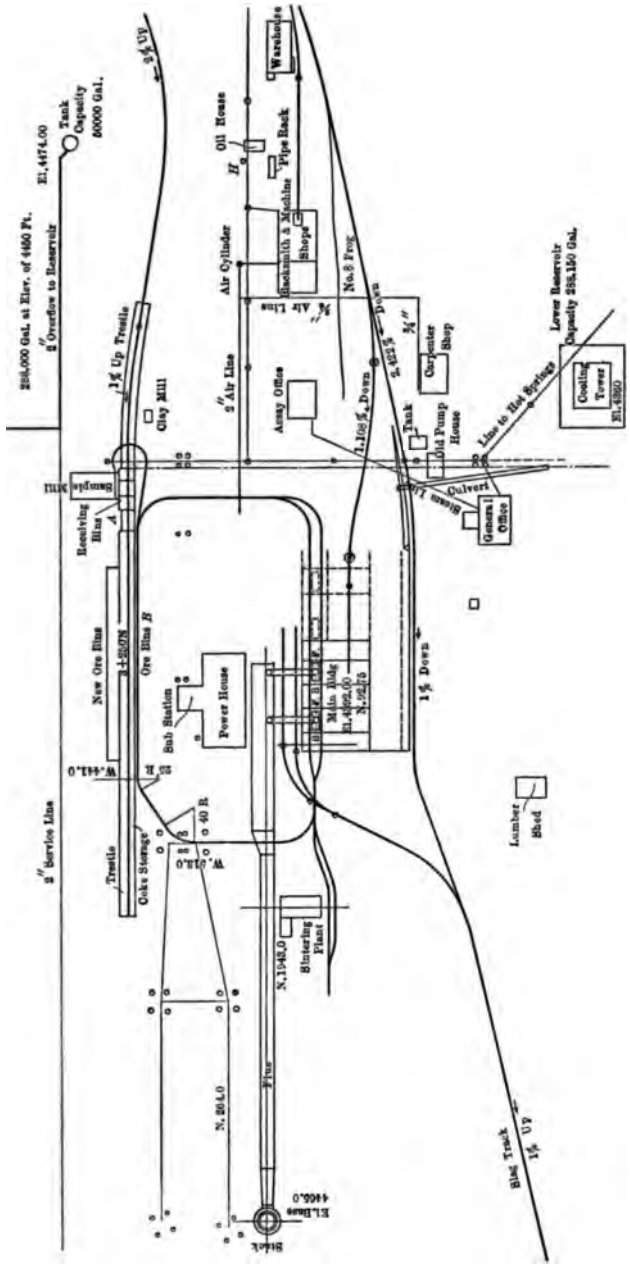
250,000 Gal. at Elev. of 4460 Ft.
8" Overflow to Reservoir
El. 4474.00
Tank Capacity 60000 Gal.
2½ Up
Warehouse
Oil House
Pipe Rack
Blacksmith & Machine Shops
No. 8 Fan
Air Cylinder
¾" Air Line
Down
Lower Reservoir Capacity 238,150 Gal.
Cooling Tower El. 4360
Carpenter Shop
Old Pump House
Line to Hot Springs
Tank
Assay Office
8" Air Line
1½ Up Trestle
Clay Mill
Sample Mill
Receiving Bins A
Blower
Culvert
General Office
New Ore Bins
Ore Bins B
Sub Station
Power House
Main Ridge
1½ Down
Lumber Shed
8" Service Line
Trestle
Coke Storage
Sintering Plant
Flue
Blue Track
1½ Up

FIG. 19.

Co., Thompson, Nev. The site was so chosen that the prevailing winds carry the smoke in the direction of the Carson sink, and for not more than 2 per cent. of the time to the agricultural lands along the Walker River. Since the smelting charge contains an average of 4 per cent. Cu, and but 6 per cent. S, there can be but little trouble to the lands in any event.

There are two blast-furnaces, one being in operation and treating 750 to 800 tons daily of ore, principally from the Nevada Douglass and Mason Valley mines, but with the addition of some custom ore. About 25 tons of limestone is used daily, as the Nevada-Douglas ore is rather siliceous.

Fig. 19 shows the arrangement of the plant. Ore, in 50-ton drop-bottom railroad cars is delivered to "Receiving Bin A" and thence transferred to the sample mill. The fine ore can be screened out if desired for separate treatment on the Dwight-Lloyd sintering machine. The rejected portion passes by a 20-in. main conveying-belt over the "Ore Bins A" called also "Charge Bins," and is provided with a tripper by which it can be discharged into anyone of the bins or into any of the ten "New Ore Bins" adjoining. These new bins, intended for custom ores, have flat bottoms, and are of 3000 tons' capacity, while the twenty "Ore Bins O" have inclined bottoms, and will hold 4000 tons. Each of these latter bins is provided with two discharge-gates and two Howe weighing hopper-scales. Referring to the "New Ore Bins," the ore from them is to be drawn out upon a belt beneath them, and delivered to the sampling mill. When sampled, it is returned by the 20-in. belt conveyor to the "Charge Bins." Thus weighing the charge is simplified, a duplication of weighing hoppers is avoided, and an accurate sample of the mixture in anyone of the new ore-bins is obtained. The bins and furnaces are connected (Fig. 19) by an elliptical track, and the ore is taken from the hoppers into a train consisting of six or seven 2-ton side-dump cars drawn by a 4-ton Jeffrey electric locomotive.

There are two blast-furnaces, 300 by 47 in. at the tuyères. From tuyères to charge-floor is 15 ft., and the charge is carried 3 ft. below the floor. These are 25 tuyères on each side, 4 in. diameter. The blast, carried at 42 oz. pressure, is furnished by two No. 11 Connersville blowers. Each blower is driven by 200 a.c. motors, and can furnish 30,000 cu. ft. of free air per minute. The furnace is charged directly from the cars. Adjustable feed plates, Fig. 20, are provided with an inclination capable of
ıstment within a range of 30 to 60 degrees. When the lower plate
ɔen set at the proper angle the coke falls in the position which gives
imum smelting rate, and it has then been found that the necessity
g down crusts and punching tuyères has disappeared, while the

furnace runs at high speed. The charge-train may consist of two cars of coke and four or five cars of ore. To charge the furnaces, the feeder raises the doors as the train approaches and as each car of coke is dumped the motor draws it the length of the furnace to distribute the contents evenly. One car of ore is next dumped then the others, already in position, follow. The operation takes 90 to 105 seconds, and a round trip of the train can be made in five to eight minutes.

The furnaces have cast-iron water-cooled tap jackets; the spout is also water-cooled, the inner sheet being of copper.

In May, 1912, only one furnace was in use. It smelted an average of 720 tons of ore and 80 of fluxes and slag daily, equivalent to 12 lb. per square foot of hearth-area per minute. This performance was with 9 to

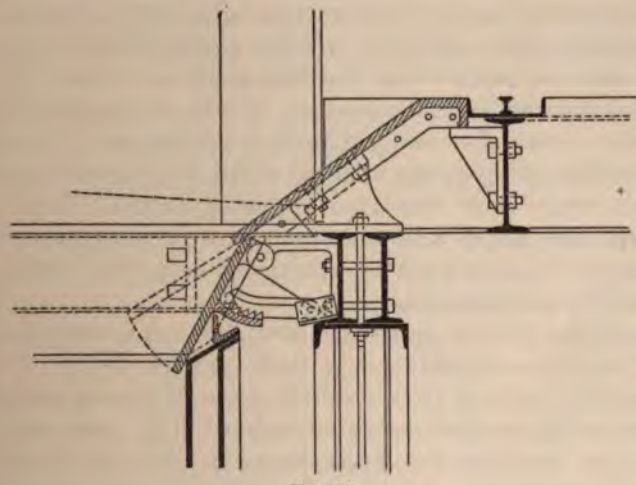

FIG. 20

10 per cent. of bulky coke containing 7 per cent. of ash. This tonnage is to be compared with 450 tons put through daily in a 15-ft. furnace at Anaconda with the same percentage of fuel and the same blast-pressure.

The first of the two furnaces is to be lengthened to 35 ft., when it is expected that 2000 tons daily will be handled by the two. Through the present furnace as high as 917 tons have been smelted daily.

The average composition of the slag is $SiO_2$, 42 per cent.; FeO, 26.8; CaO, 22; $Al_2O_3$, 7.3; MgO, 1 and CuO, 0.38 per cent.

The two settlers or forehearths of each furnace, 5 by 12 ft., are in series, but are to be replaced by a single one 8 by 18 ft. Using the smaller settlers, matte must be tapped every 30 to 45 minutes. The second settler

is tapped once a shift, and yields a few hundred pounds of matte. It is therefore useful as a guard. The slag is received in a slag-car with a bowl of 225 cu. ft. or 21 tons' capacity, hauled by a 15-ton electric locomotive. In changing pots the flow is caught in a small pot carried by a jib-crane. This is swung under the spout to catch the flow. After the change the slag thus caught is emptied into the large bowl. The practice was borrowed from the British Columbia Copper Co. The bowl of the slag-car is dumped by power controlled from the locomotive. The track on the dump is shifted by surface laborers from time to time as desired.

About 50 tons of 45 per cent. copper matte is made daily with a matte fall of 6 per cent. The matte is tapped into steel molds holding 100 lb. each, these being divided into eight compartments like a waffle iron. The molds are mounted on light steel cars to accommodate 50 molds, these cars being gradually drawn along by a 4-ton electric locomotive under the stream of matte as tapped from the forehearth, as the tapping proceeds. Tapping takes seven to eight minutes. The matte is cooled by a stream of water from a hose, then dumped into a 5-ton slag pot. The contents of the pot are then dumped into a 50-ton railroad car for shipment to Garfield, Utah, where it is converted to blister copper. This transfer is effected with the aid of a 20-ton crane having a 5-ton auxiliary. The sweepings, due to spilled matte, are loaded into small dump cars and returned to the blast-furnace.

Furnace gases pass by goose-neck down-takes to a brick dust-chamber of 500 sq. ft. section by 200 ft. long, then, by a flue 18 by 10 ft., ascends on the side hill to a stack 15 ft. inside diameter at the top by 200 ft. high. On the side of the dust-chamber adjoining the furnaces and for 50 ft. of the flue are provided automatic discharge-gates which deliver to an automatic dust-conveyor and this to a Dwight-Lloyd sintering machine. Originally it was intended to mix this flue-dust with raw sulphide ore, but the flue-dust having accumulated has been sintered by adding to it 0.5 to 2 per cent. of ground coke-dust and 8 per cent. water. The speed of travel of the grates of the sintering machine is 1 to 5 ft. per minute and the output 60 tons per day.

Electric power, used throughout the plant, is purchased from the Truckee River General Electric Co. It is received at 60,000 volts and is stepped down to 440 volts. The cost of the power is $70 per horse-power-year.

*The Tacoma Smeltery.*—This works of the American Smelting and Refining Co. has been rebuilt as a two-furnace copper plant. A wharf to ceive ore has been built upon Puget Sound parallel to the present front-, leaving a space behind it which is to be filled with waste furnace-slag

dumped from large slag-pots. Ores come in also by rail. These are unloaded into receiving bins, then taken to the sampling mill by belt-conveyor. Here occurs a separation into coarse and fine, the former going to the charge-bins direct, while the fines are agglomerated. The charge-bins are quite like those at the International plant at Toocle, Utah, in that the ore, received in a row of bins with hopper bottoms, is automatically weighed and withdrawn into charge-cars.

There are two furnaces, each 44 in. by 264 in. These are to have a capacity of 1000 tons each, due to the fact that they are to put through lump and sintered ore only. The tracks from the feed-bins run on both sides of the furnaces and the charges are side-dumped into them.

The new plant is remarkable as having been built of wood for cheapness, and no doubt also because alterations in the future can be more readily made than if of steel. It would appear that insufficient attention has been paid to the adoption of a design involving slow-burning construction.

*The White Knob Smeltery, Mackay, Idaho.*[1]—F. N. Flynn gives a description of the plant and its operations:

Two blast-furnaces, 44 by 160 in., have 13 in. side-boshes with the feed-floor 20 ft. above the tuyères.

The mine ores carried a gangue of garnet, and averaged S, 0.25 per cent.; Cu, 3.25, with approximately $SiO_2$, 34.5 per cent.; $Al_2O_3$, 7.5; Fe, 17.0 and CaO, 18.5 per cent. To furnish sulphur there was added pyrite ore from Utah, and for fluxing, a lumpy magnetite carrying Cu, 10 per cent.; $SiO_2$, 12.0; $Al_2O_3$, 7.0; Fe, 50.0 and CaO, 8.0 per cent.

In 1907, the furnaces were run with 2500 lb. charges on a 5-ft. ore-column, using 15 per cent. of coke, it having been found that with a 7-ft. column the furnace would freeze in 24 hours. Even with the 5-ft. column an iron sow soon accumulated in the crucible. Much "mush" was also formed, containing Cu, 23 per cent. and Fe, 60 per cent., which tended to choke the tap-hole, and needed vigorous rodding to remove it. At times even this expedient failed, and a sudden rush of the material would choke the furnace. For more economical working it was decided to raise the column to 10 ft. which decreased the quantity of pyrite needed, while the fuel was cut to 12 per cent. and the blast was reduced. A distributing plate was put in to deflect the falling charge, and end-doors were cut, through which to trim it. The tonnage dropped from 325 tons to a new figure of 275, and the slag temperature with it. One-third less pyrite was used and the iron oxide produced from it was effective in fluxing the ore, as against the use of a larger amount of magnetite necessary when using the lower column.

[1] *Eng. and Min. Journ.*, XCV, 747.

## COPPER AND ITS ALLOYS

*Impurities in Wrought Copper.*[1]—The American Society for Testing Materials in June, 1911, issued proposed new standards for copper, viz., that wire bars should have a conductivity of 99.5 annealed, and ingots and cake bars should have a conductivity of 97.5 annealed, excepting that arsenical copper, which should have a conductivity of not less than 95 annealed.

Ernest H. Lewis[2] considers these specifications unsatisfactory. He considers that they do not accord with the facts published by practical users, that they put the makers of "tough" copper at a disadvantage, that they do not properly consider the physical tests, and that chemical tests, not considering the impurities, have but little value. Thus copper, suitable for tough pitch, should have 0.08 to 0.1 per cent. of oxygen as cuprous oxide. Again in England tough-pitch arsenical copper carries from 0.3 to 0.5 per cent. arsenic, while lead must be under 0.1 per cent.

Commenting on this, the *Eng. and Min. Journ.* mentions a case where complaint was made by a wire manufacturer that 99.92 per cent. copper was too pure. He found that with this grade he had to slow down his drawing machines to half that used when drawing copper of 99.86 to 99.88 per cent., and he is now attempting to procure wire-bars carrying between 99.86 and 99.90 per cent.

Frederick Johnson of the Swansea Technical College, Eng.,[3] discusses the influence of impurities in tough-pitch copper.

With antimony present up to 0.3 per cent. the copper has good hot-working properties; with more than this copper oxides should be left in the copper, i.e., the metal must not be overpoled. Up to 0.5 per cent., antimony has no detrimental effect on the hot-forging qualities of tough-pitch copper free from other impurities, and it is possible to forge copper containing as much as 1 per cent. if not over-poled. To check this tendency some arsenic will aid; indeed in arsenical copper a little antimony, up to 0.1 per cent., will act in the same way, as also lead, though this latter metal is undesirable in wrought copper. Addition of lead to pure or arsenical copper causes the surface of the tough-pitch sample to sink. Further poling, to obtain a level surface, may result in rendering the metal red-short. In fact lead, like antimony and arsenic, tends to check rising of the surface in the sample. The mechanical properties of arsenical copper of 0.4 per cent. are little affected by the addition of 0.2 per cent. lead.

The addition of 0.2 per cent. tin to tough-pitch arsenical copper in-

[1] *Eng. and Min. Journ.*, XCIV, 966, 996, 1185, XCV, 191, 200; MINERAL INDUSTRY, XVIII, 222, XX, 348.
[2] *Jour. Ind. and Chem. Eng.*, Sept., 1912.
[3] *Metallurgie*, Oct. 25, 1912.

creases its hardness during rolling, but tensile strength is also increased, while elongation is lessened.

J. T. Smith[1] gives figures of a commercial American refinery showing on the average wire-bar analysis of 99.93 per cent. in 1909; 99.93 in 1910; 99.94 in 1911 and 99.95 in 1912.

Ernest A. Lewis[2] quotes standard English specifications. These are: Copper plates for fire-boxes must carry not less than 99 per cent. Cu and from 0.25 to 0.45 or 0.35 to 0.55 per cent. As, according to class; locomotive stay-bolts must carry not less than 99.25 per cent. Cu and 0.15 to 0.35 As; locomotive boiler tubes must carry not less than 99 per cent. Cu and 0.35 to 0.55 per cent. As. For conductivity-copper the requirements are for a wire 1.0 meter long weighing 10 grm. a resistance of 0.1539 ohms at 60° F., or for high-conductivity copper a resistance of 0.1508 ohms.

In notes on the metallurgy of wrought copper,[3] F. Johnson collects the recent information on the properties of the metal. He draws particular attention to its property of forging well at a redheat; its great malleability and ductility, its high conductivity, its resistances to corrosion and oxidation, its superior thermal conductivity, this latter being two and one-half times greater than iron; its toughness, tensile and torsional strength, its luster, color, and its applicability for use in the making of useful alloys.

In refining he states that, for certain brands of impure copper, poling must be stopped while the test-piece still shows some depression, for if the refining is continued until the test shows a level surface, the copper becomes red-short, and will be unfit for rolling or forging hot.

Three micrographs show the structure of the copper in the process of poling, which may be followed by the aid of Heyn's diagram, Fig. 21. Cuprous oxide is completely soluble in molten copper, but insoluble in the solidified metal, separating out as dendrites of cuprous oxide of a light blue color in a matrix of copper-cuprous oxide eutectic.

This compound, called in the diagram the hyper-eutectic (micrograph No. 1), occurs when the $Cu_2O$ is in excess of 3.5 per cent., the dendrites making their appearance as a firtree-like constituent. This is the first to separate out during cooling of the liquid solution, and its presence increases the viscosity of the copper before and during solidification, causing the copper to pour thickly. With elimination of $Cu_2O$ to 3.5 per cent. we have the eutectic (micrograph 2) which comprises an intimate mixture of minute copper and cuprous-oxide crystals termed "oxidules."

Finally, with the farther removal of oxygen, we obtain tough-pitch

[1] *Eng. and Min. Journ.*, XCV, 191.
[2] *Eng. and Mining Journ.*, XCV, 290.
[3] *Met. and Chem. Eng.*, IX, 396.

copper, the hypo-eutectic (micrograph No. 3), where there are two constituents, first, copper crystals which have separated out from the liquid solution leaving the mother liquor (solution of cuprous oxide in copper) to furnish the said crystals with copper, and, second, the solid eutectic itself.

Mr. Johnson advances a theory to account for the behavior of copper during poling. When poling starts, the molten copper is saturated with $Cu_2O$. The effect of poling is to rapidly reduce the $Cu_2O$ with an evolution of CO and $H_2O$. As the poling progresses, and the proportion

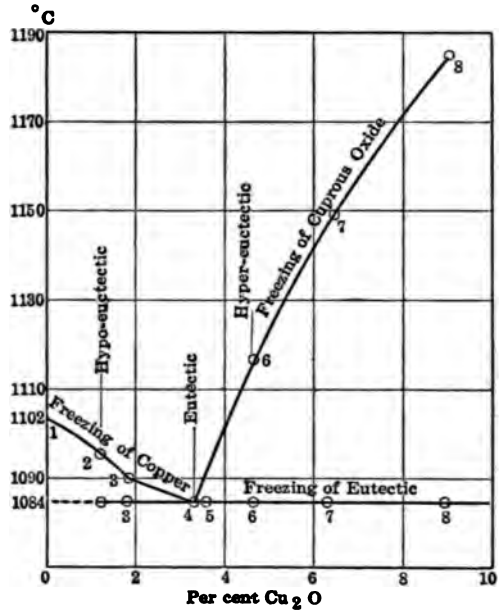


FIG. 21.

of metallic copper increases, the latter keeps dissolving some of the evolved gases formerly insoluble in the presence of much $Cu_2O$. As oxygen is removed so the gases are the more dissolved, chiefly hydrogen, probably produced from the hydrocarbons in the wooden pole. If sample-ingots be taken of under-poled, tough-poled and over-poled copper, as represented by micrograph No. 1, 2, and 3 respectively and their fractures be examined, it will be seen that: the fracture of No. 1 is "dry" with no silkiness of grain and no vesicular cavities; the fracture of No. 2 will be silky with tiny vesicular cavities uniform in size and distribution; in No. 3 the fracture is still silky but there are more cavities, some of them larger than others, the larger ones occurring near the surface. These cavities are evidently filled with gas released at the moment of solidification. The

bubbles of gas, by reason of their natural buoyancy, exerted an up thrust which tended to oppose the effect of liquid shrinkage and so prevented the depressed surface. In the case of No. 3, or overpoled copper, the cavities occurred in such quantities as not only to oppose the formation of a depression but to elevate the surface and to form the "worm" or projection of semi-molten copper.

*Effect of Mechanical Work on Copper.*—Copper, after hot-forging, is stronger, more ductile and of closer grain than the cast metal. Hot-rolling can be carried to such an extent as to confer on the copper a tenacity, which the same copper, after severe cold-working and annealing, cannot exceed. Hot-working should be stopped at such a temperature as will allow a certain amount of molecular rearrangement to take place following on the distortion, or otherwise should have the closest and finest crystalline structure attainable, but must not show the confused structure obtained by working the metal at a too low temperature. Subsequent cold-working may then be possible to a greater extent before annealing will be necessary. Progressive cold-working increases tensile strength and the limit of elasticity, but diminishes extensibility. Le Chatelier states that pure copper can attain a breaking strength of 50,000 lb. per square inch when drawn into wire, but this cannot be exceeded even by repeated drawing. Annealing has the effect of lowering tensile strength but of raising elongation.

Cold-working may produce a state of instability which may render the metal susceptible to "age-cracking or secular brittleness, regarding which two theories have been set forth:

Beilby thinks that those soft crystals, which are near to the boundary between them and the hard ones, assume a hard amorphous condition, which confers on the metal by virtue of this intercellular hardness greater elasticity and tensile strength, greater brittleness and reduced toughness. In short, cold-working distorts the crystals, causing gliding of the crystalline elements over one another along the planes of the least cohesion. The hard amorphous boundary-crystals, instable as they are, revert to the soft crystalline state upon annealing.

Ewing and Rosenhain present the theory of "slip-bands" thus: If metals are submitted to stress, and at the same time their polished surfaces are viewed under the microscope, the development of these slip-bands may be clearly seen; they increase in number as the stress increases. When fracture occurs, parting takes place along a line coinciding with the least adhesive slip-bands or "gliding-planes" which have been developed through each crystal while submitted to stress. When the structure is fine the line of fracture will be straight and well defined, when coarse it will be less regular and serrations will appear. We may

expect (a) metal of homogeneous fine structure to be stronger than (b) heterogeneous metal having fine and coarse crystalline areas, or than (c) homogeneous metal of uniformly coarse structure. In case (b) rupture will occur when the structure is coarse. In case (c) gliding-planes will be fewer but more pronounced, and their development will be less hindered by the restraining action of the less-crystalline planes of greater adhesion, these planes being more frequent in the finer structure, case (a).

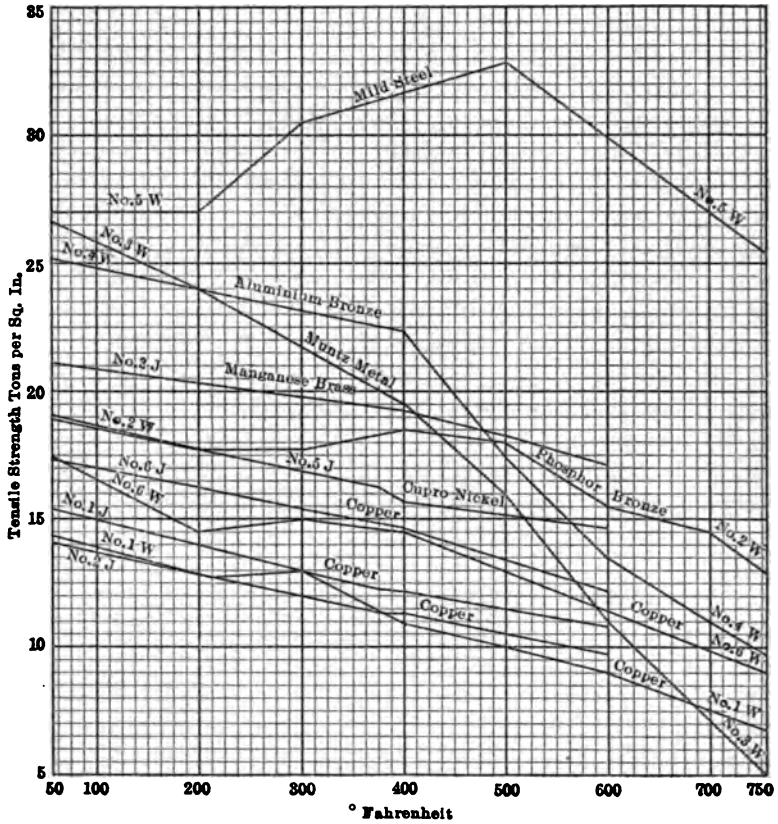


Fig. 22.

*Behavior of Copper and Its Alloys at High Temperatures.*—Fig. 22 shows the weakening effect of increasing temperatures on copper, its alloys and for comparison upon mild steel.

*Tests for Copper Plate for Locomotive Fire-boxes.*[1]—The Standard specifications of the Lancashire & Yorkshire Ry. are:

Bending test: Pieces of the plate shall be tested cold and also at a

[1] "Modern Copper-smelting," D. M. Levy; Mineral Industry, XVIII, 222.

red heat by bending to 180 degrees without showing crack or flaw. Flanging: Plates must be without defect in flanging. Tensile test: Ultimate breaking load 31,000 lb.; elongation 35 per cent. in 8 in. Copper to contain 0.35 to 0.55 per cent. As, other elements, exclusive of oxygen, not to exceed 0.25 per cent.

Typical plates contain 99.3 per cent. Cu; 0.45 to 0.51 per cent. As, and 0.1 per cent. O. Other impurities, not exceeding 0.25 per cent., are Sb, Pb, Ni, Sn and S. An average of a number of plates gave the following physical results, tensile strength 33,000 lb., elongation in 8 in. 43.36 per cent., contraction in area 45.9 per cent., and the plates stood the close-bending test.

*Specification of Copper Wire for Telegraph and Telephone Service.*[1]—The specification for Nos. 13 and 10 wire (Birmingham wire gage) as given for the British postoffice service is as follows:

No. 13 Wire: Weight per mile, 150 lb.; minimum diameter, 95 1/2 mills; maximum diameter, 98 mills; minimum breaking strain, 490 lb.; minimum number of twists in 3 in., 25; maximum resistance per mile at 60° F., 5.857 ohms; must wrap six times around wire of its own diameter, unwrap and be again wrapped without breaking.

No. 10 wire: Weight per mile, 500 lb.; minimum diameter, 135 1/4 mills; maximum diameter, 138 3/4 mills; minimum breaking strain, 950 lb.; minimum number of twists in 6

[1] Modern Copper Smelting, D. M. Levy, 19.

ANALYSES OF VARIOUS COMMERCIAL COPPERS.[1]

| | Cu. | Au. | Ag. | Pb. | As. | Sb. | Bi. | Fe. | Ni. | Sn. | O. | S. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Electrolytic conductivity copper. | 99.89 | nil | nil | nil | 0.016 | Tr. | nil | 0.042 | 0.006 | ..... | 0.008 | nil |
| (2) Lake copper..... | 99.77 | nil | 0.029 | nil | nil | Tr. | nil. | 0.0077 | 0.0146 | nil | 0.070 | nil |
| (3) Best-select copper | 99.75 | ..... | ..... | 0.024 | 0.025 | Tr. | 0.011 | 0.10 | 0.061 | ..... | 0.143 | ..... |
| (4) Tough-pitch copper. | 99.41 | ..... | ..... | 0.070 | 0.320 | Tr. | 0.010 | 0.010 | 0.060 | ..... | 0.120 | ..... |
| (5) Fire-box plate ran 500,000 miles. | 98.70 | 0.0001 | 0.0346 | 0.4085 | 0.3726 | 0.3746 | 0.0360 | 0.0069 | 0.3039 | ..... | 0.0181 | 0.0064 |
| (6) Cathode copper . | ..... | ..... | 0.001 | 0.00034 | 0.00034 | 0.0008 | 0.0003 | ..... | ..... | ..... | 0.005 | ..... |
| (7) Black copper.. | 97.70 | ..... | 0.2133 | 0.78 | 0.052 | 0.2380 | 0.0035 | 0.17 | ..... | ..... | ..... | 0.796 |
| | 94.39 | ..... | 0.11 | 0.19 | Tr. | ..... | ..... | ..... | 2.04 | 0.07 | ..... | 0.80 |
| (8) Cement copper (Spanish). | 51.90 | ..... | 2.35 | 1.45 | 2.95 | 0.50 | 0.95 | 7.0 | ..... | ..... | 16.00 | 5.10 |
| | 76.93 | 0.10 | ..... | Tr. | 1.32 | 0.02 | ..... | 7.6 | ..... | ..... | ..... | 0.48 |
| (9) Blister copper... | ..... | 0.0009 | 0.04 | 0.042 | 0.108 | 0.157 | 0.055 | 0.4 | 0.2 | 0.5 | ..... | 0.112 |
| (10) Chili bar..... | 98.60 | ..... | ..... | Tr. | 0.100 | Tr. | nil | 0.009 | ..... | ..... | ..... | 0.909 |

[1] "Modern Copper Smelting," Levy, p. 44.

in., 30; maximum resistance per mile at 60° F., 2.928 ohms; must wrap like No. 13 wire.

*Removal of Impurities in Copper Refining.*[1]—Stahl describes the removal of impurities in slagging. He thus summarizes:

(1) The metallic impurities are not only slagged as silicates, but as ferrite and other oxygen compounds, arsenates and antimonates.

(2) Graphic curves, illustrating the removal of impurities, must show not only the proportions, but the principal conditions when these change.

(3) Zinc, iron, cobalt and tin are removed to traces at the beginning of the roasting which follows the oxidation poling. The removal of the nickel, lead and antimony extend through the whole refining process. Silver and bismuth are only eliminated in small quantities, silver almost entirely by volatilization.

*Refining Copper.*—A method of refining molten copper has been devised by Walter A. Rockey[2] and Hilliary Eldridge, of New York, N. Y. To carry out the process the copper is first fused and then poured into a fused bath of boron trioxide, or one containing that compound. The inventors prefer to carry out the process by causing the copper to flow downward into the flux, through the flux and upward out of the flux. During this time of contact the temperature is maintained at the required point to expel all or a majority of the occluded gases and to permit solution of the oxides by the fused boron trioxide (1,027,769, May 28, 1912).

*The Wear of Bronzes as Affected by their Composition.*[3]—Portevin and Nusbaumer, in a monograph entitled "Essais sur l'usure des bronzes," sum up the result of their researches as follows:

(1) The wear of bronzes is proportional to their tenor in tin, and generally according to the amount of $\delta$ constituent.

(2) Phosphorus makes an average bronze, wearing less than a high-tin bronze and more than a low-tin one.

(3) When the bronze rubs on a polished steel bearing with full lubrication, a hard thin film forms on its surface, but if this film is broken the wear becomes rapid.

(4) The tendency to crystallize, due to tempering the bronze, favors
of the film.

*of Copper and its Alloys at High Temperatures.*[4]—G. D.
experimentally investigated maximum stresses and elon-
eratures up to melting point. From his summary of
the following broad conclusions:

877.
X, 433.
eb., 1912, LXI.
I, 123.

Fig. 23 is a combined diagram to illustrate a whole series of tensile curves, in which copper, brass of 70 per cent. Cu and 30 per cent. Zn, and copper-nickel are represented by the curve *XYZ;* and cast-brass, Muntz metal, and a complex brass by the curve *XYV*. Copper shows an acute change at its point of recuperation at 650° C., indicated by the point *Y*.

The horizontal distance *BC* shows the difference in strength at a temperature of 250° C. between the cast and rolled alloys. As the temperature rises this difference gradually diminishes, disappearing at *Y*.

Above *Y* the behavior of these materials resembles that of a viscous liquid. Now below the recuperation temperature, an alloy tends to

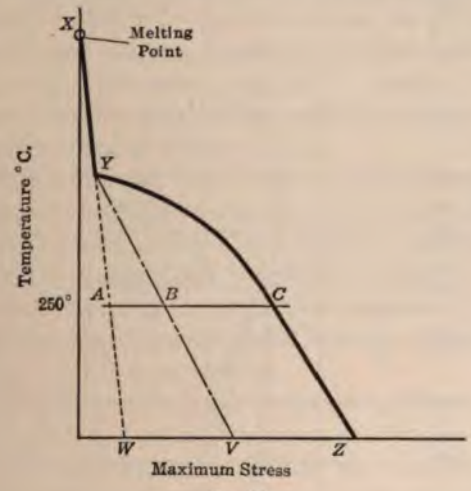


Fig. 23.

fracture through its crystals rather than between the crystalline junctions, so we may reasonably conclude that the individual crystals are bound together by some substance stronger than the crystals themselves; this being Beilby's "amorphous material" arranged in a thin continuous layer around the crystals. At temperatures above *Y* it may be supposed that the amorphous material, which cements the crystalline faces, is no longer able to exist, so that slip will take place at the crystalline junctions and among the crystals, the resulting material instantly recrystallizing. Thus "work" will no longer strengthen the metal and "will leave the alloy in a perfectly soft condition. Cold work would be carried out below the temperature of recuperation.

Referring now to Fig. 23, the difference of strength indicated up to *AB* 250° C. by the line *ABC*, will be due to the work put on it by rolling or forging.

The general type of elongation curve for copper is shown in Fig Elongation rapidly increases above the point of recuperation (650° At 920° C. it falls rapidly, probably due to lack of cohesion, and rea zero at the melting point. The abrupt changes in the mechanical perties as above outlined do not occur at phase-change temperature

*Copper-zinc Alloys; a New Critical Point.*[1]—Prof. H. C. H. Carpe and C. A. Edwards have made an exhaustive research on the prope

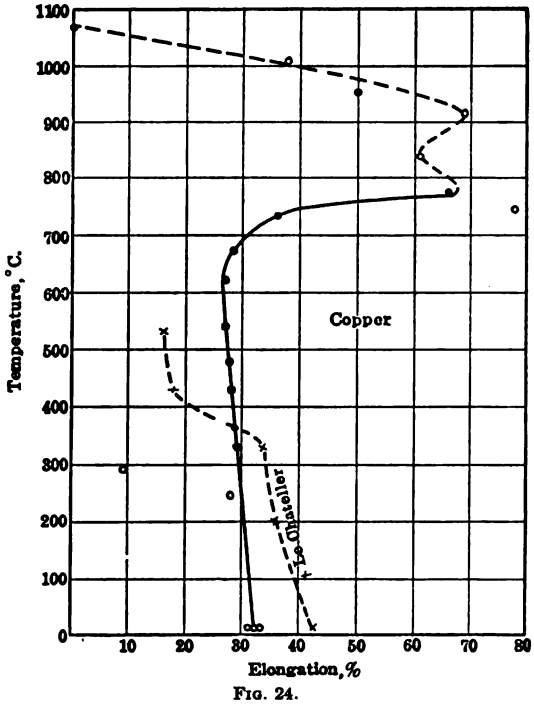


FIG. 24.

of brasses at this temperature, and their paper has been followed b extended discussion by other metallurgists. They give a summary o results of their work which I briefly state.

A thermal change has been pyrometrically detected at 470° C. i alloys of 40 to 63 per cent. Cu containing the $\beta$ constituent as a seps structural entity. It is interpreted that at 470° C. on cooling $\beta$ split into an intimate mixture of $\alpha$ and $\gamma$ and on heating the reverse ch takes place. Alloys, containing $\alpha$ constituent, are to be regarde homogeneous mixtures of very minute crystals of copper and $\beta$.

In an alloy of exactly the eutectoid composition the structural is so remarkable, that even after six weeks' annealing at 445

[1] *Inst. Metals*, V, 127.

no appreciable coalescence has been observed. When a few crystals of either $\alpha$ or $\gamma$ are present, then on annealing at 445° C. the stability is easily destroyed. These crystals form nuclei for the deposition of teh rest of the $\alpha$ or $\gamma$, as the case may be, from the mixture. The structural stability of the eutectoid was so diminished by the addition of 4 per cent. aluminum, that after two days' annealing at 445° C. it was found to have undergone a typical lamellar inversion.

The practical consequence of the critical point is the brittling of the alloy, owing to the brittle properties of $\gamma$. This explains the crystallization and brittleness of alloys containing apparently only $\alpha$ constituent, which appears with the lapse of time at ordinary temperatures and much more rapidly at 300 to 400° C. It throws light on the causes of various types of corrosion and decay of brasses, and particularly on the corrosion of condenser-tubes of marine engines in service.

The brittleness can be entirely removed by heating for a short time above 500° C. and cooling at ordinary rates.

*Brass Containing Tin and Lead.*[1]—In a paper discussing the microstructure of brass, F. Johnson explains that it is advisable to thoroughly anneal castings of the composition Cu, 70 per cent.; Zn, 29; Sn, 1 per cent.; or naval brass of the composition Cu, 62 per cent.; Zn 37 and Sn, 1 per cent., before subjecting them to mechanical treatment, in order that the brittle tin compound may pass into solid solution; also to afterward cool naval brass slowly for the same reason.

*Distinguishing Colors of Copper-zinc Alloys.*[2]—When the alloy contains 5 per cent. of zinc it has a red color, scarcely differing from copper. At 10 per cent. zinc the alloy has a true bronze color, at 15 per cent. the color is of a light orange; at 20 and 25 per cent. the mixture is greenish-yellow and is known as "green brass." Brass with 30 and 35 per cent. zinc has the true yellow brass color. At 40 per cent. a reddish-yellow color is found. When the zinc has increased to 45 per cent. it is of a rich golden yellow, which may be termed orange. The alloy containing 50 per cent. zinc has a golden color, richer even than that of 45 per cent. At 55 per cent. the color resembles 14-karat gold. When 60 per cent. zinc is reached the brass has a yellowish-white shade, and as the quantity increases the color becomes white and finally gray. All these appearances are to be judged upon a dull and not on a polished surface.

*Losses in Melting Brass-scrap.*[3]—R. A. Ward gives actual losses that are experienced in melting scrap in large batches. They amount to about 5 per cent., and at times to 6 or 7 per cent. Some 65 per cent. of coke was needed to melt it.

[1] *Journ. Inst. Metals*, VII, 201.
[2] *Brass World*, Sept., 1912.
[3] *Metal Industry*, Sept., 1912.

*Making Brass Cheaply.*[1]—Lawrence Addicks, Chrome, N. J., has patented a cheap method of making brass. Copper is drawn off from a cathode melting furnace into a ladle capable of holding 2 or 3 tons; zinc in the required quantity is then introduced into the ladle. The zinc promptly melts and the resultant brass is poured from the ladle into molds, forming ingots of whatever shape are desired. This is effected at little more cost than performing the same operation in casting copper.

*Cast Copper-zinc Alloys of* 47.5 *to* 100 *Per Cent. Cu.*[2]—In 1905, the Alloys Research Committee[3] investigated the properties of worked brasses. The present investigations refer to cast brasses and were made by W. D. Bancroft and J. M. Lohr. If a 60-per cent. copper alloy is quenched, after heating to 800° C., it crystallizes to pure $\beta$ metal; if quenched between 470° and 740° it will consist of $\alpha$ and $\beta$ crystals, and if below 470° then $\alpha$ and $\Gamma$ crystals show under the microscope. This last, as is the case with the slowly-cooled metal, is brittle. Above 67 per cent. Cu the $\alpha$-state alloy tests 30,000 to 36,000 lb. per square inch. From 67 to 55 per cent. $\beta$ crystals predominate, and the strength increases to 71,000 lb.; below 55.4 to a composition of 47.5 per cent. the strength drops to 24,000 lb.

As compared with these cast metals, the annealed brasses, owing to increased size of grain, are weaker, the worked brasses owing to their smaller grain are stronger.

## Costs

*Cost of Mt. Lyell Copper.*[4]—For the half-year ending Sept. 30, 1912, the cost of the company for mining and treatment was:

| | |
|---|---|
| Mining 153,243 tons | $2.33 |
| Removing overburden, 50 cents per ton on 21,523 tons of open-cut ore | 0.07 |
| Underground development, 8 cents per ton on 74,724 tons of ore mined underground | 0.04 |
| Smelting 157,296 tons ore | 2.10 |
| Converting | 0.25 |
| Freight and selling expenses | 0.59 |
| | 5.23 |
| Office-expense, prospecting, taxes, depreciation | 0.92 |
| Total per ton of ore | 6.30 |

*Costs at the Great Cobar, Ltd.*[5]—In 1911 this property treated 346,303 of ore of 1.8 per cent., yielding 6548 tons of blister copper, and valued 330,000, or $5.28 per ton. The costs per ton are: Mining, $2.26; g, $1.78; converting, $0.42; total, $4.46; being a cost of 10.7 cents d of blister copper produced. If we estimate that the expenses

[1] *Min. Journ.*, XCIV, 1084.
[2] *Cong. Appl. Chem.*
[3] *Mech. Engrs.*, LXXIX, (1905).
[4] *Sci. Press*, CVI, 184.
[5] *Sci. Press*, CV, 234.

of refining and marketing are covered by the precious metals obtained, the property should be profitable.

*Costs at Cananea.*[1] —L. D. Ricketts, Mgr. of the Cananea Copper Co. gives the operating costs of the company in 1911. The smelting costs per long ton of new copper-bearing material have been greatly reduced since 1907 as herewith: In 1907 the cost per ton was $6.82; in 1908, $3.86; in 1909, $3.09; in 1910, $2.69; and 1911 it was $2.57.

The reduction works treated 580,060 dry tons at the following segregated costs: Sampling, $0.0222; bedding, $0.0584; reclaiming, $0.0202; blast-furnace costs, $1.4055; reverberatory costs, $0.3197; calcining costs, $0.0510; converting costs, $0.6518; indirect custom-ore costs, $0.0351; flux, $0.0071, making a total of $2.57 per dry ton of new copper-bearing material, or, on a basis of 50 lb. produced per ton of ore treated, 5.142 cents per pound of copper.

The cost of roasting in McDougal furnaces was 40 cents per ton made up thus: Sampling, bedding and reclaiming, $0.1262; operating roasting furnaces, $0.1894; transportation of calcines, $0.0228; general expense and flux, $0.0619; a total of $0.4003.

Of the total charge to the reverberatory of 113,782 tons, there was, of flue-dust from the blast-furnaces, 41,883 tons; calcines, 66,299 tons; fluxes, 1194 tons, and of silicious ore, 4406 tons. The cost of smelting a ton of charge was $1.65 including $0.223 per ton due to repairs and rebuilding of the two furnaces. This leaves $1.427 net, including rebuilding, thus distributed: Labor operating, $0.2982; labor of repairs, $0.1547; shop-expense, $0.0151; supplies and material, $0.2070; power, $0.0095; fuel-oil, $1.4882; cost of flux, $0.0223, and sundry expenses, $0.0566; making a total of $2.2516. From this there should be credited for steam produced at the waste-heat boilers $0.8245, leaving as above $1.4271 per ton. Adding the cost of rebuilding $0.2232 we have the total cost of reverberatory smelting $1.6503.

The recovery from ores was, copper 2.5 per cent. or 50 lb. per ton, silver 1.0718 oz. and gold 0.005 oz. per ton.

## Recent Progress in Electrolytic Refining of Copper Bullion and in the Hydrometallurgy of Copper

By Arthur L. Walker

At the end of the year 1912 the capacity of the electrolytic refineries in the United States was 1,579,000,000 lb., as shown by the following table, comparisons being made with figures given for the capacity at the end of the year 1911.

[1] *Min. and Sci. Press*, CV, 565.

ELECTROLYTIC COPPER REFINERIES OF THE UNITED STATES.

| Works. | Location. | 1911 Capacity, Pounds. | 1912 Capacity, Pounds. |
|---|---|---|---|
| Nichols Copper Co. | Laurel Hill, N. Y. | *330,000,000 | *330,000,000 |
| Raritan Copper Works | Perth Amboy, N. J. | °320,000,000 | †360,000,000 |
| Baltimore Copper Smelt. & Rolling Co. | Canton, Md. | *288,000,000 | °312,000,000 |
| American Smelting & Refining Co. | Perth Amboy, N. J. | *180,000,000 | °192,000,000 |
| U. S. Metals Refining Co. | Chrome, N. J. | °180,000,000 | °180,000,000 |
| Balbach Smelting & Refining Co. | Newark, N. J. | °48,000,000 | °48,000,000 |
| Anaconda Copper Mining Co. | Great Falls, Mont. | °65,000,000 | °65,000,000 |
| Tacoma Smelting Co. | Tacoma, Wash. | *28,000,000 | °36,000,000 |
| Calumet & Hecla Mining Co. | Buffalo, N. Y. | °55,000,000 | °55,000,000 |
| Total | | 1,494,000,000 | 1,578,000,000 |

° Official figures furnished by the respective companies. * Estimated. † Will soon be increased to 408,000,000 lb. per year.

The capacity of the refineries for electrolytic copper has increased during the past eight years from 800,000,000 lb. per annum to the above figures, or approximately 100 per cent. This increase has been gradual in order to take care of the additional output from the various mines, especially from the low-grade porphyry properties.

Many of the plants mentioned have during this period increased the size of their electrolytic tanks and of the anodes used, so that the dimensions of the latter are now 3 ft. by 3 ft. It has been thought inadvisable to still further increase the size of the anodes on account of the difficulty of maintaining a proper alinement during the last portion of the cycle, when the anodes become very thin and are apt to sag. Anodes having a larger area would also be more difficult to cast properly. Apparently, therefore, if any further increase in the size of the tanks is made it will be done without increasing the size of the anodes, but by placing them parallel in a wider tank.

The progress that has been made in electrolytic copper refineries in the last two years has been largely in the nature of mechanical improvements and, as a result, better work is being done all the time, both in the nature of the copper produced and in operating costs.

At the Chrome, New Jersey, plant of the United States Metals Refining Co.,[1] Mr. Lawrence Addicks has made a very careful study of the problem of casting copper, and in organizing the casting department it has been arranged so that the furnaces deliver copper to the casting machines at three different periods during the day and the casting crews on the machines, in shifts of eight hours each, are always on duty. This enables one casting machine crew to serve several furnaces and eliminates delay in the work of these men due to any delay in the operation of the furnace itself.

[1] Private communication to the writer.

Basic reverberatory furnaces at the Chrome plant have been successfully developed for this casting work and have given very satisfactory results, although the details are not yet open for publication. The successful application of the recharging principle covered by the United States Patent No. 980584, granted to Addicks and Marks, has resulted in a very marked increase in the capacity of the casting plant, and has increased the tonnage of the furnaces to a very great extent. The essential feature of this process is melting and refining a charge of copper in the furnace and after a certain portion of this charge has been poured and cast, adding cathodes in such a way that these cathodes are immediately melted without being affected in any way by oxidation from the furnace gases, the cathodes sinking into the mass of hot molten copper in the furnace. In carrying out this plan, approximately 350,000 lb. of copper are originally melted and refined, and while casting this copper about 150,000 lb. more are added, making a total of 500,000 lb. in the charge. By this means, not only is the capacity of the furnace greatly increased but over one-third of the copper is melted without being subjected to oxidation and slagging. The average charge now is about 470,000 lb. of copper.

It has been found at this plant that it is good policy to produce very high grade anodes in the casting department, as in doing so a great advantage is gained in the tank room department in being able to place the anodes nearer together and increasing the current density without lowering the current efficiency. Not only does the production of perfect anodes cast from high poled copper accomplish these results, but the silver and gold losses in the cathodes have been greatly decreased. In a recent month the silver and gold content of the wire bars only amounted to 12 cents a ton when the value of gold and silver in the anodes was $56 a ton. This is exceptional work and indicates the very close relation between the condition of the anode and the cathode losses.

The loss in silver and gold in treating silver from the electrolytic tanks has been attracting the attention of refiners for some time. While some of the plants are adopting the Cottrell system to reduce these losses in fume, at the Chrome plant they have been at work for several years on a wet process which it is believed will entirely suppress the unknown silver losses. Though it is not possible to obtain an exact description of this process at the present time, it is stated that the process is based on roasting the slime under such conditions that a large part of the silver is soluble in sulphuric acid, the resulting silver sulphate being precipitated as a chloride. It will be interesting to learn how this process works out and to have a comparison between it and the regular fire method followed by the Cottrell system recovery apparatus.

At the American Smelting and Refining Company's plant at Pert Amboy, N. J., great attention is also being paid to the condition of th anodes, and experiments have been made with the idea of preventin arsenic in the anodes from entering the electrolyte. In order to do this sufficient amount of nickel has been added to the anode copper to form a alloy with the arsenic, which is not affected by the electrolytic action an remaining insoluble passes into the slime. A careful experiment mad with this end in view where the anode copper contained 0.5 per cen nickel and 1.77 per cent. arsenic showed that the cathodes resulting fro the electrolytic treatment of these anodes contained only 0.0015 per cen arsenic and 0.0030 per cent. antimony, while the slime contained ov 5 per cent. nickel. The cathodes were smooth and a wire drawn from th cathode copper had a conductivity of 101.18 per cent. During the te the average composition of the electrolyte was acid 7.85 per cent., C 2.13 per cent.; As, 1.72 per cent.; Ni, 1 per cent.; Cl 0.0033 per cent. Co sidering the large amount of arsenic in proportion to the copper the cath odes were exceptionally pure. Mr. Robert L. Whitehead, who is in charg of the tank room department, is perfecting a device for a contact betwee the cathode and anode bar which should save about 10 per cent. of th power. He is applying for a patent on this device and the details will b available later.

At the Raritan Copper Works, Perth Amboy,[1] a change has been mad in the current density and Mr. Clark, the superintendent, writes that i has been found advisable to increase the number of electrodes in the refin ing tanks, and, consequently, the anode surface, thereby decreasing th current density from about 20 amperes per square foot to 17 or 18 amperes This is a decided change, as until recently the current density in ou various refineries has been steadily increased. The temperature of th electrolyte is being maintained at a very high point, as it is found that b this means smoother cathodes are produced and though the cost o obtaining this temperature is considerable the decrease in power, due t the decrease in resistance of the electrolyte, offsets to a great extent th extra cost of heating the electrolyte. Great stress has been laid on pro ducing a refined copper of the highest quality and at the Raritan Work the conductivity of the refined copper has averaged well over 100 per cen Large furnaces for casting copper are also being installed at this plant— these furnaces now having a capacity of 400,000 lb. per charge. In thi connection it might be mentioned that although no definite data is obtain able on the subject it is rumored that the Nichols Copper Co. is building copper casting furnace at their plant at Laurel Hill, L. I., which will hav a capacity of 700,000 to 800,000 lb. of copper per day.

[1] Private communication to the writer.

The Baltimore Smelting and Rolling Co.[1] is installing a small multiple plant, using the Walker system for the arrangement of the tanks, with the intention of treating more impure copper than has been customary in the series system. This plant, however, is only designed for copper which is very impure, as in their series system itstlf they are treating copper with contains more impurities than it was believed possible to handle. The difficulty was in rolling copper which contained more than a small amount of arsenic, antimony, nickel and lead, but at the present time by their new system for rolling they are producing rolled anodes for their series tanks which contain between 5/10 and 6/10 of 1 per cent. of these impurities. This is a very important matter in connection with the series system and partly eliminates one of the disadvantages which has always been claimed for this system, and consequently one of the points which has always been in favor of the multiple system.

In connection with the desirability of producing copper of a very high grade, attempts have been made in recent years to melt cathode copper in such a manner that it will not be contaminated with impurities absorbed from the gases which come in contact with the molten bath. Messrs. Rockey and Eldridge[2] have been working on this problem for several years and have made several attempts to accomplish this result, but up to the present time their work has not been successful. They are still working on this problem, however, and now suggest an apparatus by which some of the former difficulties are overcome. The copper is fused by an oil jet in one compartment and then flows by a conduit into another compartment, in which, by suitable means, the ingress of contaminating gases is prevented. From the second compartment the copper is cast as fast as it is received in a molten condition. The mechanical arrangement of this device seems open to criticism. However, the proposition of melting and casting copper without allowing the copper to become contaminated by the impurities from the gases is a very important one, and it is hoped that the problem will be successfully worked out in the near future.

Mr. Addicks, in his plan previously mentioned, accomplishes this result with a certain portion of the cathode copper cast, and in a very satisfactory way.

While progress is being made in the electrolytic copper refineries in this country, great improvements have also been made abroad. The electrolytic refinery of the Kyshtim Corporation in Perm County, Russia, is now being operated on a satisfactory basis and is taking care of the increased production of this company. The Bogoslov Mining Co.

[1] Private communication to the writer.
[2] *Met. and Chem. Eng.*, Vol. X, No. 2, Feb., 1912.

is considering the installation of an electrolytic copper refinery to handle their product. The refineries in Australia are being conducted according to the best modern practice. At the refining plant of the Great Cobar,[1] the electrolyte is heated to 130° F., contains 12 per cent. of sulphate of copper, 12 per cent. of sulphuric acid, and this composition at this high temperature gives the minimum resistance to the electric current. The silver and gold slime is treated with strong sulphuric acid to remove copper and then is melted with proper fluxes, cast into Doré anodes and the Doré parted electrolytically byt he Moebius system.

The electrolytic refinery at Nikko,[2] Japan, has been enlarged to meet the demand imposed upon it by the increased output of copper. The new addition contains 108 tanks in twelve groups of nine tanks each, arranged according to the Walker system. The tanks are made of wood and lined with 8-lb. sheet lead. A group of nine tanks is 9 ft. by 30 ft. and 4 ft. deep. The anodes used are 2 ft. 3 in. wide, 3 ft. long and $1\frac{1}{4}$ in. thick, while the cathode strips are 2 ft. 4 in. wide, 3 ft. long and $\frac{1}{32}$ in. thick. A single tank will hold 18 anodes and 19 cathodes, spaced 4 in. centers. At present the anodes are left in the tanks about 21 days and the cathodes seven days. The current density used is 20 amperes per square foot. The electrolyte enters at the top of the tank and escapes at the bottom, the rate of flow being 100 cu. ft. per hour. The best results are obtained where the electrolyte is warmed to 104° F. to 122° F. The annual output is expected to be 9,000,000 lb. of refined copper.

## Hydrometallurgical Processes

In spite of the attention which has been devoted to wet processes for the extraction of copper from its ore, great difficulties have been encountered in the solution of the problem and up to the present time it can hardly be said that a successful solution has been effected, though in several localities it seems as though the chance of solving this problem on certain classes of ore is, to say the least, encouraging.

The work of the Bradley process at Anaconda has been discontinued on account of mechanical difficulties which were encountered and the results obtained were not satisfactory from a mechanical or financial standpoint. We are informed that in the same locality a wet process being perfected for a new 80-ton plant, which is expected to be running the middle of July, 1913. Details of this process have not been made le, and it is stated that the condition at present does not warrant

and *Chem. Eng.*, Vol. X, No. 2, Feb., 1912.
and *Sci. Press*, Oct. 12, 1912.

doing so. It is said that up to this time experiments indicate that the plant will be a complete success for the satisfactory extraction of copper from low-grade ore and tailings.

An undertaking of great magnitude, from which much has been and is expected, is being made in Chile by the Braden Copper Co., where a plant to extract copper from the concentrate produced, which runs about 20 per cent. copper, by a wet method, is now about completed. The concentrate will be roasted so that the iron will be in the form of an insoluble oxide, and the copper mainly as an oxide with a small amount as sulphate. The fumes from the roasting furnace will pass through a condenser, when the $SO_2$ will be recovered as sulphuric acid, which will be used for leaching the copper from the roasted concentrates. The supply from this source will be ample. By this method it is expected to obtain an extraction of 95 per cent. The solution from the leaching operations will carry 5 per cent. copper and be delivered to electrolytic tanks, where the copper will be deposited on prepared copper cathodes, the operation being continuous till the copper content of the electrolyte is reduced to 1½ per cent. It will then be run back to the leaching plant and, after the addition of more acid, used again. Provision, however, will be made to remove one-quarter of the electrolyte daily in order to prevent impurities, which are dissolved from the concentrate, accumulating, and by this means it is expected to keep the electrolyte sufficiently pure to make good electrolytic copper. This leaching process, at theB raden Copper Co.'s plant, will be in competition with the smelting and converting method for treating these concentrates, and the result will be watched with a great deal of interest. Fortunately, at this property, the cost for power for the electrolytic work is low.

At the Chuquicamata plant, the new Guggenheim enterprise, it is proposed to leach the entire product and it is stated that the chances for success are most encouraging. Applications for patents on the process are being filed, and until this protection is effected very little can be learned about this enterprise.

In regard to the new leaching plant at the Reduction Works of the Shannon Mine, Ariz.,[1] Mr. J. W. Bennie states that the experiments commenced last year, leading to an attempt to solve the economic treatment of low-grade semi-oxidized ores, have been continued during the past year, with every assurance that the problem will be solved. Several months were wasted in the anxiety to rush these experiments, and they are not, therefore, much farther advanced than they were last year. He believes that the process they are experimenting with is successful to the extent that it renders the major portion of the copper content soluble

[1] *Min. and Sci. Press*, Dec. 21, 1912.

in water. Mr. T. T. Read,[1] writes in regard to the process used at Shannon, that while they are unwilling to disclose results, Mr. Bennie, the superintendent, has recently patented a method of heap-roasting and leaching in which the heaps during roasting are sprinkled with solutions containing $FeSO_4$ or NaCl, or both, to aid in converting the copper into sulphites and sulphates as completely as possible, followed by leaching and subsequent precipitation and, presumably, this is the procedure followed.

The question of roasting ore for hydrometallurgical treatment is a most important one and has been carefully investigated by Mr. Utley Wedge, of Ardmore, Pa.,[2] the idea being to roast ores containing copper oxide, carbon or silicate in the presence of sulphurous gases whereby the copper is converted into copper sulphate, which may be washed out by water. From the solution thus obtained the copper may be precipitated in any desired manner. The preferred form of furnace for the operation is a muffle furnace of the superimposed hearth type designed by the inventor (U. S. Patent No. 1043400, Nov. 5, 1912). In operation, the ore is fed into the furnace on the top hearth, and sulphurous gas is admitted at the bottom hearth or any other that may be preferable. The gas should contain not less than 3 per cent. by volume of $SO_2$, and preferably 14 to 16 per cent. Some oxygen will have to be admitted with the gas to permit of conversion of the copper ores into copper sulphates. The temperature should be maintained at 800° F. to 1100° F., and care should be taken to prevent so high a temperature that the formed copper sulphate will be decomposed. An effective manner of carrying out the process is to use it in connection with an ordinary roasting furnace, the hot sulphurous gases from which can be conducted directly into the furnace in which the copper ore is being treated.

From the above it can be seen that metallurgists and investigators have recently been very busily engaged in devising processes for the extraction of copper from ore by wet processes, and also that up to the present time none of these propositions have been definitely successful, although great things are expected from some of the installations, notably

the Braden Copper Co.'s plant, at Chuquicamata and at Anaconda.

outcome of these experimental plants will be watched with great

t.

problems involved in hydrometallurgical methods for copper are

cult, more difficult than the solution of the problem for extracting

its ore by the cyanide process. In the latter case a very small

metal having a great value is dissolved, whereas in the former

aratively large amount of metal must be dissolved in order to

[1] *Min. Press.*

[2] *Eng. &*

, 1912

effect the desired result. In doing this, large quantities of other metals are dissolved and the solution contaminated. Again, the precipitation of gold from the cyanide processes is a comparatively easy proposition, whereas in the case of copper in solution, if a chemical is used the operation is either very expensive or else other metals besides copper are precipitated, and if electrolysis is used to deposit the copper out of solution by means of insoluble anodes a comparatively large amount of power is required, fully seven times that required for the deposition of copper from an electrolyte when soluble anodes are used.

As the writer stated in a short article in the *Eng. and Min. Journ.* last January, "The difficulties which the metallurgist must overcome in order to introduce a satisfactory wet process for treating copper ore are fully recognized, but the demand for such a method at present is so great that a successful solution of the problem is hoped for in the near future. Mr. T. T. Read[1] expresses the proposition more tersely in the following words, "The task of finding a profitable wet method is like that which faced the small boy sent to dig out a woodchuck; it must be accomplished."

[1] *Min. and Sci. Press*, Sept. 12, 1912.

# COPPERAS

The sulphate of iron production in 1912 amounted to 41,713 short tons valued at $420,000, as compared with 35,501 tons valued at $390,500 in 1911. The following table gives the production of copperas in the last 15 years:

PRODUCTION OF COPPERAS IN THE UNITED STATES.
(In tons of 2000 lb.)

| Year. | Short Tons. | Value. | Year. | Short Tons. | Value. | Year. | Short Tons. | Value. |
|---|---|---|---|---|---|---|---|---|
| 1898..... | 11,285 | $58,105 | 1903..... | 20,240 | $121,440 | 1908..... | 35,334 | 388,674 |
| 1899..... | 13,770 | 108,508 | 1904..... | 16,956 | 118,692 | 1909..... | 42,225 | 464,475 |
| 1900..... | 12,374 | 96,517 | 1905..... | 21,103 | 147,721 | 1910..... | 38,896 | 427,856 |
| 1901..... | 23,586 | 112,336 | 1906..... | 22,839 | 228,390 | 1911..... | 35,501 | 390,500 |
| 1902..... | 19,781 | 118,474 | 1907..... | 26,771 | 294,481 | 1912..... | 41,713 | 420,000 |

Copperas is obtained as a by-product in pickling sheet iron, steel and wire, preparatory to galvanizing or tinning. For this reason the United States Steel Corp. is the largest producer. Other producers are the Westmoreland Chemical & Color Co., Philadelphia, Pa., E. I. Du Pont De Nemours Powder Co., Wilmington, Delaware, Wickwire Brothers, Cortland, N. Y., Pennsylvania Salt Co., Philadelphia, Pa., and the Stauffer Chemical Company, San Francisco, Cal. A large proportion of the copperas produced by manufacturers is converted into venetian red for paint makers. It is also converted into rouge to a small extent. This production of copperas is not included in the table.

The uses of copperas were enumerated in MINERAL INDUSTRY, Vol. XX, p. 257. O. W. Story describes the pickling processes in steel works.[1]

The production of copperas in foreign countries is a large industry. Prices were quoted in Liverpool at the beginning of 1912, at $9.12 per ton. Belgium produces about 5000 tons annually. At Ghent, copperas is obtained from roasted pyrites. In addition Belgium produces about 600 tons of rouge and colcothar.

1 Met. and Chem. Eng., Jan., 1913, p. 35.

# CORUNDUM

For certain purposes some established trades still prefer the natural abrasive corundum or emery to alundum, carborundum, etc. The mineral corundum is more or less pure oxide of aluminium crystallized and having a hardness of nine. Emery is the rock containing corundum, magnetite, etc., intimately associated, and deriving its abrasive quality chiefly from the corundum present. In the United States corundum has been mined in Gallatin County, Montana, Raburn County, Georgia, and Macon County, North Carolina, but in recent years production has ceased. The tables of production in these years, therefore, refer to emery. Emery is mined at Chester, Hampton County, Mass., and near Peekskill, Westchester County, New York. These mines have been regular producers and supply a small part of the consumption in the United States. On account of this limited production, and also on account of preference as to grade for particular kinds of trades, a large importation of emery takes place each year, chiefly from Greece, and to some extent from Canada.

STATISTICS OF CORUNDUM AND EMERY IN THE UNITED STATES.

| Year. | Production. (a) | | Imports. | | | | |
|---|---|---|---|---|---|---|---|
| | | | Grains. | | Ore and Rock. | | Other Mfrs. |
| | Short Tons. | Value. (b) | Pounds. | Value. | Long Tons. | Value. | Value. |
| 1899 | 3,970 | $ 228,570 | 728,229 | $29,124 | 7,435 | $116,493 | $11,514 |
| 1900 | 5,030 | 247,100 | 661,482 | 26,520 | 11,392 | 202,980 | 10,006 |
| 1901 | 4,305 | 146,040 | 1,086,729 | 43,217 | 12,441 | 240,856 | 10,926 |
| 1902 | 4,251 | 104,605 | 1,665,737 | 49,107 | 7,157 | 151,959 | 13,776 |
| 1903 | 2,542 | 64,102 | 3,595,239 | 109,272 | 10,884 | 194,468 | 17,829 |
| 1904 | 1,932 | 57,235 | 2,281,193 | 109,772 | 7,054 | 138,931 | 11,721 |
| 1905 | (c)2,315 | 19,677 | 3,209,914 | 143,729 | 11,072 | 185,689 | 17,996 |
| 1906 | (c)2,147 | 22,780 | 4,655,168 | 215,357 | 13,840 | 286,386 | 19,105 |
| 1907 | (c)1,069 | 12,294 | 4,282,228 | 186,156 | 11,235 | 211,184 | 15,282 |
| 1908 | (c) 669 | 8,745 | 1,735,366 | 89,702 | 8,084 | 146,105 | 12,592 |
| 1909 | (c)1,580 | 18,185 | 2,696,960 | 132,264 | 9,836 | 186,930 | 19,803 |
| 1910 | (c)1,028 | 15,077 | 1,189,664 | 53,709 | 16,321 | 344,421 | 13,527 |
| 1911 | (c) 659 | 6,778 | 1,382,813 | 76,027 | 10,822 | 245,459 | 15,158 |
| 1912 | 992 | 6,652 | 2,135,922 | 105,325 | 16,391 | 379,529 | 16,871 |

(a) Statistics of the United States Geological Survey for 1901–1912. (b) Values have not much significance owing to the wide variation in the quality of the materials combined in the totals. (c) Emery only.

*Imports.*—The imports of corundum and emery are classified into the corundum ore, emery ore, and corundum grains, and emery grains; the last two manufactured, ground, pulverized or refined. Of these, the emery grains are dutiable at 1 cent per pound, and the others are free. In 1912 the corundum ore imported was 593 long tons valued $84,944 or 6.35 cents per pound. The emery ore imported was 15,798 tons valued $284,585 or $18 per ton. The corundum grains imported were 1,344,255 lb. valued $72,449 or 5.35 cents per pound; the emery grains imported were 791,667 lb. valued $32,876 or 4.2 cents per pound. In addition, manufactures of emery, such as wheels, files, etc., are imported to some extent and are dutiable as 25 per cent. But the exports of these manufactures far exceed in value the imports. The exports including other abrasives were $1,482,971 in 1911 and $2,007,463 in 1912; of the latter more than one-third was in the form of emery wheels. No notable fluctuation in this trade is likely to occur inasmuch as the consumers require a regular supply of regular quality. The old uses for the imported product are apparently not replaced by new abrasives.

*Canada.*—Two properties in Ontario have for years produced corundum, namely the Craig mines and the Burgess mines. These are now under the control of the Manufacturers' Corundum Company. The former property is the larger producer. The following table shows the production of corundum in Canada:

PRODUCTION OF CORUNDUM IN CANADA.

| Year. | Short Tons. | Value. | Year. | Short Tons. | Value. | Year. | Short Tons. | Value. |
|---|---|---|---|---|---|---|---|---|
| 1900.... | 60 | $ 6,000 | 1905.. | 1,644 | $149,153 | 1910.. | 1,870 | $198,680 |
| 1901.... | 534 | 53,115 | 1906.. | 2,274 | 204,973 | 1911.. | 1,472 | 161,873 |
| 1902.... | 1,137 | 83,871 | 1907.. | 1,892 | 177,922 | 1912.. | 1,960 | 239,091 |
| 1903.... | 1,119 | 87,600 | 1908.. | 1,089 | 100,398 | | | |
| 1904.... | 1,665 | 150,645 | 1909.. | 1,491 | 157,398 | | | |

The production in 1912 was 1960 tons valued at $239,091. A slight increase in the price per pound in recent years, is to be recorded; namely in 1910, 5.31 cents per pound; in 1911, 5.5 cents per pound, and in 1912, 6.1 cents per pound. The imports of emery were valued $46,606 during 1912.

*Greece.*—The production of emery is chiefly from the Island of Naxos, whence the product is shipped under government control. During 1909 the production was 10,965 metric tons, but the sales amounted to only 8,193 tons; during 1910 the mines produced 8000 tons, whereas the sales amounted to 12,939 tons: in 1911, 9845, tons. The average price in 1910 was $19.71. The following table shows the exports:

EXPORTS OF EMERY FROM NAXOS, GREECE.

| Year. | Metric Tons. | Value. | Year. | Metric Tons. | Value. | Year. | Metric Tons. | Value. |
|---|---|---|---|---|---|---|---|---|
| 1897.... | 3,125 | $ 65,683 | 1903.. | 5,813 | $120,348 | 1909.. | 8,193 | $164,762 |
| 1898.... | 4,500 | 93,166 | 1904.. | 6,353 | 131,531 | 1910.. | 12,939 | 255,053 |
| 1899.... | 5,139 | 106,181 | 1905.. | 6,395 | 132,090 | 1911.. | 9,845 | 202,119 |
| 1900.... | 6,023 | 124,503 | 1906.. | 8,030 | 166,251 | 1912.. | 7,837 | 157,452 |
| 1901.... | 6,080 | 125,582 | 1907.. | 10,982 | 221,154 | | | |
| 1902.... | 4,315 | 88,841 | 1908.. | 7,471 | 164,520 | | | |

The emery industry of Naxos yielded to the International Finance Commission a revenue of $255,110 in 1910, and $202,215 in 1911.

This commission represents the foreign governments in Greece, and the revenues are used in the payment of the old international debt of Greece. During 1912 there was a prolonged strike.

The exportation of the emery of Naxos in 1911 amounted to 9845 tons, valued at $202,119, and was distributed as follows: to the United States, 4322 tons; Germany, 1400 tons; Holland, 1378 tons; France, 1165 tons; Belgium, 670 tons; Great Britain, 540 tons; Spain, 350 tons, and Austria-Hungary, 20 tons.

The emery deposits at Naxos, occur in three zones, the two upper ones being finely granulated and associated with more finely crystallized limestones.

*Germany.*—Germany produces some emery and also largely manufactures imported emery. The emery produced in Bavaria in 1910, amounted to 270 tons valued at 12,050 marks, and in 1911, 210 tons valued at 9400 marks. Emery cloth manufacture is a considerable trade as shown by the following figures of imports into Switzerland in 1911: 172,040 lb. valued $23,488; of which total $18,673 in value came from Germany, the balance from Great Britain and France.

*India.*—A considerable increase in the output of corundum for the year 1911, is reported. In 1910, 2748 cwt., valued at £634; and in 1911, 8045 cwt., valued at £1675. With the exception of 185 cwt., the whole output came from Madras. 180 cwt. were produced in Rewa, and 5 cwt. in Kashmir. The output in Kashmir is from the sapphire mines, being blue corundum or corundum-bearing rock.

*Turkey.*—The last official report of the Department of Mines and Forests is for the fiscal year ending March 1909; 62,352 metric tons of emery were produced valued at £85,381 in 1908 and 24,475 metric tons, valued at £80,000 in 1909.

*Transvaal.*—A new discovery of corundum was made toward the end of 1911 on the upper ridges of the watershed, 7 or 8 miles from the Oliphants River, and west of the Mashishimali Ranges. The deposits, according to J. Broad-Roberts,[1] are associated with a mica belt and

[1] *Journ.* of the South African Inst. of Eng.

occur in a variety of forms. One is an irregular vein of feldspar and quartz, about 4 ft. wide, in which sapphires also are found. The foot-wall is a calcareous tuff, the hanging a talcose and micaceous decomposed schist.

At two other points lenses of ruby granular corundum were discovered. Associated kyanite and fushite occur here and translucent rubies from the size of pinheads up to over 1 in. in diameter and 4 in. long. Nearby are small veins of Alexander garnet. At another point a lens of some size contains gray crystals in a matrix of clear, micaceous rocks and a schistose sediment. Other deposits of granular corundum ore are also known.

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# CRYOLITE

Only one occurrence of cryolite has been developed, and this is situated at Ivigtut, Greenland, the Danish Colony. The mine belongs to the Oresunds Chemiske Fabriker, Copenhagen, Denmark. Here the product of the mines is treated in part and sold to various consumers or manufactured into chemical products. The production at the mine for the calendar year 1912, amounted to 9945 metric tons of cryolite. Of this 8041 tons were treated at the works in Copenhagen, and the balance, namely, 1904 tons, was shipped directly from Greenland to the United States. In 1911 the exports of this company[1] from Copenhagen, were 1600 tons to France; 1300 tons to Germany; 760 tons to Austria; and 700 tons to England. The total exported was 6000 metric tons.

The chemical composition of cryolite is a fluoride of sodium and aluminium, having a fusing point of 1000° C. The preparation for the market and the uses of cryolite are described in MINERAL INDUSTRY, Vol. XX, p. 263.

The only indications of cryolite in the United States, according to the United States Geological Survey, have been in minerals found for Pikes Peak, Colo. There is no likelihood, however, of a commercial deposit. The deposit in Greenland is a solid mass having surface dimensions of about 200 by 600 ft. The mine is worked as an open cut with a depth of about 150 ft. The deposit widens in depth and the depth is unknown.

Formerly cryolite was used in the soda and alum industry, but now it is used almost entirely for the metallurgy of aluminium. The Pennsylvania Salt Company is the sole importer in the United States.

The Department of Commerce reports the following imports: 1910, 36 tons valued at $2343; 1911, 2007 tons valued at $47,093; 1912, 2126 tons valued at $48,293. The average values stated for these years are therefore: 1910, $65 per ton; 1911, $23.50; 1912, $22.70.

Canada is also an important producer of aluminium and the average importations of cryolite are about 200 tons per year. The cryolite is imported entirely from the United States, although a small shipment from Austria was reported for the fiscal year ending March 31, 1912. The imports for that year, from the United States into Canada, were in excess of the average, being 400 tons valued at $35,639 or $89 per ton. Cryolite is entered free both in the United States and Canada.

[1] *Journ. du Four Electrique.*

# DIATOMACEOUS EARTH

This material was formerly used to a considerable extent as an absorbent substance in the manufacture of dynamite, in which use at the present time it is replaced by other substances. A limited production in the United States is consumed by manufacturers of insulating material, and as an abrasive. It is also used in filters. For most uses the material is dried at a high temperature and ground.

The distribution of the material is almost universal as the diatoms, or minute living organisms, that leave siliceous skeletons live in either fresh or salt water, hot or cold. They act as water-purifiers, with the aid of the action of sunlight, giving off oxygen obtained from the carbonic acid of the air.

The production of this substance together with tripoli, is given under the article on "Quartz" in this volume. Tripoli is of a different nature, being a residue from siliceous limestone. In the United States diatomaceous earth or diatomite, occurs and is being mined in California, Nebraska, Connecticut, Georgia, Maryland, New York and Virginia. The largest deposits exist in California, where they are of considerable purity, being free from iron especially. The production of California, including probably some tripoli, in 1911[1] was 2194 tons valued at $19,670. About two-thirds of this production came from Santa Barbara County, and one-third from Monterey County. In 1910 the production of California was 1843 tons, valued at $17,617.

Diatomite is produced in Austria, England and Australia. The deposits near Carlsbad, Austria, are owned by the Government, and the material is used in small quantities for the manufacture of statuary, etc. The Kieselguhr, as it is known in Germany, is used for a variety of purposes, in the manufacture of pottery, papier-maché, putty, adulterants for soap, catchouc, and as an insulator of heat. In Belgium are large factories using German "Infusorial Earth," in the manufacture of ultramarine. France is a large consumer, chiefly for insulating. In England no diatomite was quarried during the last few years. The production in 1909 from the British Diatomite Company, operating on the Isle of Skye, was 240 tons valued at £120. One of these deposits 40 ft. in thickness.

In 1911, the deposit at Talbot, Victoria, Australia, produced 400 tons

[1] Calif. State Mining Bureau.

valued at £1600. This deposit was operated by the Kieselguhr Company. The occurrence is described[1] by D. J. Mahony, who gives a list of other localities. The better qualities of diatomite are generally associated with basalt, with which they are either interbedded or or in which they may fill depressions. The chief deposits are at Lillicur, where diatomite has been mined for years. One deposit in this locality completely fills a basin-shaped hollow in the basalt, the maximum depth being 171 1/2 ft. and the area 4 1/2 acres. The deposit is estimated to contain 60,000 tons. It is horizontally stratified, and snowy white containing occasionally some yellow opals. The output in recent years has been: 1909, 800 tons valued at £2400; 1910, 500 tons valued at £2000; 1911, 400 tons valued at £1600. Infusorial earth valued at $607 was shipped to the United States from Algeria in 1911.

[1] *Bull.* No. 26, *Geol. Survey, Victoria*, 1912.

# FELDSPAR

The quantity and value of the product has not fluctuated very much for recent years. The statistics are as follows:

FELDSPAR IN THE UNITED STATES. (a)
(In tons of 2000 lb.)

| Year. | Crude. | | Ground. | | Total. | |
|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| 1902..... | 21,870 | $ 55,501 | 23,417 | $194,923 | 45,287 | $250,424 |
| 1903..... | 13,432 | 51,036 | 28,459 | 205,697 | 41,891 | 256,733 |
| 1904..... | 19,413 | 66,714 | 25,775 | 199,612 | 45,188 | 266,326 |
| 1905..... | 14,517 | 57,976 | 20,902 | 168,181 | 35,419 | 226,157 |
| 1906..... | 39,976 | 132,643 | 32,680 | 268,888 | 72,656 | 401,531 |
| 1907..... | 31,080 | 101,816 | 60,719 | 457,128 | 91,799 | 558,944 |
| 1908..... | 18,840 | 65,780 | 51,634 | 362,773 | 70,474 | 428,553 |
| 1909..... | 31,037 | 85,421 | 45,502 | 316,367 | 78,707 | 415,131 |
| 1910..... | 24,655 | 81,965 | 56,167 | 419,486 | 80,822 | 501,451 |
| 1911..... | 28,131 | 88,394 | 64,569 | 490,614 | 92,700 | 579,008 |
| 1912..... | 26,462 | 89,001 | 60,110 | 431,561 | 86,572 | 520,562 |

(a) Statistics reported by the U. S. Geological Survey for 1911 and 1912; other years the same, except for New York.

PRODUCTION OF FELDSPAR BY STATES.
(Crude and Ground. In tons of 2000 lb.)

| | 1910 (a) | | 1911 (a) | | 1912 (a) | |
|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| Connecticut.... | 18,739 | $ 89,974 | 16,497 | $ 73,557 | 19,075 | $ 94,097 |
| Maine..... | 20,762 | 196,463 | 25,976 | 246,305 | 19,091 | 173,076 |
| Maryland..... | 9,977 | 47,340 | 12,694 | 56,265 | 9,231 | 55,998 |
| New York (b).. | 12,132 | 46,863 | 15,652 | 61,769 | 22,192 | 101,525 |
| Pennsylvania .. | 15,091 | 104,751 | 13,284 | 101,090 | 9,451 | 71,287 |
| Other States... | 4,121 | 16,060 | 5,449 | 21,865 | 7,532 | 24,579 |
| Total..... | 80,822 | 501,451 | 89,552 | 560,851 | 86,572 | 520,562 |

(a) U. S. Geological Survey. (b) New York State Geological Survey.

The industry is not large, but it has been long established in connection with pottery. The industry is not dependent on foreign imports excepting those from Canada. These were 12,779 tons valued $44,114 in 1912. According to the United States Census figures for 1909, the expenditure for mining and equipment in that year of 28 quarries was $238,896.

Of the United States production in 1912, 1750 short tons valued $17,102, were used for abrasives and 12,500 tons, valued $37,500 for roofing, concrete surfacing and poultry grit. The price of crude spar was $3.36 in 1912 and $3.14 per ton in 1911; for ground spar it was $7.18 $7.60 in these years.

The principal producers are New York, Maine, Connecticut and Pennsylvania and Maryland.

Feldspar is valuable on account of its physical property of angular cleavage and also on account of its chemical composition. Two varieties are distinguished commercially, the potash and the soda feldspars. The theoretical composition of pure orthoclase or of microcline is 64.7 per cent. silica, 18.4 per cent. alumina, 16.9 per cent. potash. The last may be more or less replaced by soda. Such feldspars form a glass on fusing and are useful in the pottery industry. Lime soda feldspar recrystallizes and is not used for pottery glazes.

In Vermont, California and North Carolina, feldspar production is a new industry. The deposit near Chester, Vt., is large and now being worked steadily by A. L. Stone. A mill has been built for grinding the rock which is partly orthoclase and partly plagioclase. The ground material is sold for use in making china ware. The California spar comes from Tulare and Monterey Counties. The production in 1911 was 740 tons of crude material valued at $6 per ton at the quarries.

A large amount of feldspar has been thrown on the dump at Baringer Hill in the course of mining the pegmatite dike for the rare earth minerals.[1]

*New York.*—By D. H. Newland. The state produces feldspar of various grades adapted for nearly all purposes to which the mineral is put. In fact, the only sort that is not produced by the local quarries to any extent is the high-grade pottery spar which occurs in some places, but has not proved profitable to handle on account of the extra care required in its preparation. The recent growth of the domestic pottery business, however, may lead soon to the development of this branch, at least on a scale sufficient to meet the needs of the nearby markets. The other uses include roofing material, enamel ware, for glazing of brick, tile and terra cotta, in opalescent glass, as an abrasive in the manufacture of scouring soaps and powders, as a binder in the manufacture of emery, carborundum and corundum wheels, and to a smaller extent for poultry grit, concrete and grout. For the last three purposes, as well as for roofing material the pegmatite is crushed unsorted.

The principal development during the past year has been the opening of the new quarries in the vicinity of Bedford, Westchester County. The Bedford Feldspar Co., began active production on property adjoining the Kinkel quarries, where it has erected a mill of 40 tons daily capacity for grinding the spar. Its product goes into enamel ware, opalescent glass, etc. Kinkel and Son continued work in their main quarries and also developed a new quarry two miles south of Bedford, obtaining

[1] Llano Burnet folio, *U. S. Geol. Surv.*

from the latter a high-grade potash spar. Their mill is being overhauled and will be equipped with cylinders for making the best grades of finished material.

In North Carolina, the Carolina Mineral Co. operates in Mitchell County.

In foreign countries the production of Canada is important as shipments have been made for many years to the United States. Bedford, Ontario, is a heavy producer. The spar is a red orthoclase, which however contains so little iron that it burns white. The consumption is chiefly by potteries at Trenton, N. J. A mill for grinding feldspar was erected a mile and a half from Parham Station, on the Kingston-Pembroke Railroad. The feldspar for grinding purposes is brought from Bobs Lake. Shipments of crude feldspar to the United States from the Richardson mines continued steadily through the year.

The Richardson feldspar mine, owned and operated by the Kingston Feldspar & Mining Co., is still the largest shipper in Ontario. The feldspar is mined by open-cut work, and during the past year the area of the workings has been enlarged without any increase in depth. The productions of Canada in 1910, 1911 and 1912 were 15,809 short tons, 17,723 tons and 12,233 tons respectively, valued $47,667, $51,939 and $25, 416. The exports for these years were 15,601 short tons valued at $47,962; 16,150 tons valued $56,085; and 12,779 tons valued $44,114 in 1912. The selling price of crude at Trenton, N. J., averages $5 per long ton; it contains nearly three-fourths potash feldspar. Quebec produced 110 tons in 1912 and 30 tons in 1911. The deposits are on Manicouagan Bay, opposite the island of Anticosti.

In Norway several mills have recently been built for the grinding of feldspar, that hitherto chiefly has been exported in lumps. There is every prospect of this exportation being now changed from lump into ground feldspar. The exportation of feldspar from Norway was in 1911, 35,000 tons. Norway exported about 40,000 tons of different grades of feldspar in 1912; about 3000 tons of this was ground. Sweden imports a small quantity; 106 tons in 1912; the production however is large and is reported for 1910 as 21,591 tons and for 1911 36,235 tons. In Germany, Bavaria reported a production of 2,620 tons valued 43,960 marks in 1910; and 3,165 tons valued 56,270 marks in 1911. Germany in 1912 imported 58,297 tons and exported 15,466 tons.

*Heat Insulating Properties of Feldspar.*—According to the experiments of C. P. Randolph,[1] feldspar at a temperature of 100° C. has thermal resistivity of 17° C. per watt per cubic inch. For comparison this quality of asbestos is given under "asbestos."

[1] *General Electric Review*, Jan., 1913.

# FLUORSPAR

By F. Julius Fohs

The fluorspar industry during 1912, for the first time reached a generally sound basis, the domestic output having exceeded 100,000 tons and the value of total consumption $1,000,000. These improved conditions are directly traceable to the $3 per ton import duty, to better management, and to the keeping of development ahead of production, all of which the writer has long contended necessary to proper development of this industry. Of course, the increased demand from the steel plants and other consumers is also a necessary factor.

Illinois and Kentucky continued the chief producing states with Illinois greatly in the lead, owing chiefly to the more advanced development of its mines. Colorado, New Mexico, and possibly New Hampshire were also producing states in 1912 but their aggregate output was small. The accompanying table shows at a glance the production and condition of the industry for the year.

FLUORSPAR PRODUCTION, 1912.

| | Mined Tons. | Tons. | Marketed Value. | Average Value per Ton. | Stock, Dec. 31, 1912. |
|---|---|---|---|---|---|
| Illionois | 103,681 | 104,971 | $747,854 | ..... | 6,340 |
| Kentucky | 13,570 | 13,416 | 99,983 | ..... | 3,125 |
| Other States (a) | 5,000 | 5,000 | 28,500 | ..... | ..... |
| Totals | 122,251 | 123,387 | $876,337 | $7.10 | 9,465 |
| Imports | ..... | 26,174 | 141,726(b) | $5.26 | ..... |
| Total apparent consumption | ..... | 149,561 | $1,018,063 | ..... | ..... |

(a) Estimated and includes Colorado, New Mexico and New Hampshire.
(b) Inclusive of duty, thus being value f.o.b. Atlantic port.

Of the total domestic fluorspar marketed in 1912, there were 108,376 tons crude valued at $673,405 and 15,011 tons ground valued at $202,932.

The material betterment of conditions over 1911, is shown by 41.8 per cent. increase in amount of domestic spar marketed with an increase of 43.1 per cent. in value. The apparent consumption has increased 24.5 per cent. while there has been a decrease of about 29 per cent. in imports. Imports in 1910 were 42,488 tons and in 1912 26,174 short tons The demand for ground fluorspar increased 17 per cent. and for crude per 23 cent.

The average value of all grades f.o.b. mines for 1912 was $7.10 as against $7.02 in 1911. The average value of crude was $6.21 as against $6.10 and of ground was $13.52 as against $12.38 the year previous. Even the value of the imported spar increased, it being $6.06 f.o.b. Atlantic port in 1912 as against $5.46 in 1911, per long ton.

The range of prices for domestic gravel was from $5.65 to $7, for lump from $7 to $8.50 and for ground $10 to $16. The large variation in prices for ground was due to sale in bulk or barrels, quantity sold, and grade. The percentage of lump marketed has gradually decreased until it represents less than 5 per cent. of the total marketed, while the percentage mined is less than 20 per cent. of the total. With the decrease in production of lump there has come also a decrease in the amount of clear white fluorspar produced. The stock tonnages mean very little since these represent only the stock above ground whereas in certain of the large mines there is from 15,000 to 20,000 tons per mine now kept shot down in the stopes ready for haulage and hoisting; this is in keeping with the better business basis upon which the industry is now established. Small amounts of galena and zinc blende are produced as by-products.

Foreign fluorspar is imported chiefly from England, where the chief producers obtain it as a by-product in concentrating lead ore.

The mines of J. Cameron Swan & Co., Ltd., in the Weardale district, England, County of Durham, afford a regular output of 15,000 to 20,000 tons of washed lump and gravel spar. This spar is of very high quality and much of it is exported to the United States.

The fluorspar in the United Kingdom from mines in Durham and quarries in Derby are as follows: The total production in 1911 was 55,213 tons, and in value was £18,941 as compared with 61,621 tons, valued at £20,678, in 1910.

The value of fluorspar at the mines in Bavaria, Germany, was $2.28 per metric ton in 1910 and $2.35 in 1911. Spain produced 499 tons in 1911, the average value at the mine being $1.92.

PRODUCTION OF FLUORSPAR IN THE UNITED STATES.
(In short tons.)

| Year. | Mined. | Value. | Per Ton. | Year. | Mined. | Marketed. | Value. | Per Ton. |
|---|---|---|---|---|---|---|---|---|
| 1901 (a). | 19,586 | $113,803 | $5.81 | 1907 (b) .. | 39,777 | 38,922 | $223,308 | $5.76 |
| 1902 (a). | 48,018 | 271,832 | 5.19 | 1908 (b) .. | 46,677 | 38,795 | 225,998 | 5.83 |
| 1903 (a). | 42,523 | 213,617 | 4.28 | 1909 (b) .. | 45,801 | 50,843 | 301,704 | 5.94 |
| 1904 (a). | 36,452 | 234,755 | 6.44 | 1910 (a) .. | ..... | 69,427 | 430,196 | 6.20 |
| 1905 (b). | 38,918 | 228,543 | 6.32 | 1911 (a) .. | ..... | 87,048 | 611,447 | 7.02 |
| 1906 (b). | 31,592 | 211,231 | 5.70 | 1912 (b) | 122,251 | 123,387 | 876,337 | 7.10 |

(a) Statistics of U. S. Geological Survey. (b) Statistics collected by F. J. Fohs. The figures for 1905 to 1908 inclusive differ slightly from those obtained independently and reported by THE MINERAL INDUSTRY for these years. (c) Estimated.

FLUORSPAR OUTPUT OF THE PRINCIPAL PRODUCING COUNTRIES.
(In metric tons.)

| Year. | Austria-Hungary. | France. | Germany. | Spain. | United Kingdom. | United States. |
|---|---|---|---|---|---|---|
| 1899.... | 4,959 | 5,140 | 24,306 | 310 | 796 | 21,806 |
| 1900.... | 5,649 | 3,430 | 30,310 | 4 | 1,471 | 19,646 |
| 1901.... | 5,774 | 3,970 | 28,741 | *Nil.* | 4,232 | 17,768 |
| 1902.... | 5,902 | 2,650 | (*a*)14,177 | 93 | 6,388 | 47,190 |
| 1903.... | 5,445 | 2,447 | (*a*)13,028 | 4,000 | 12,102 | 38,577 |
| 1904.... | 7,061 | 2,047 | (*a*)13,540 | (*b*) | 18,451 | 33,069 |
| 1905.... | 7,601 | 2,434 | (*a*)15,019 | (*b*) | 40,079 | (*c*)35,299 |
| 1906.... | 7,795 | 4,218 | (*a*)15,493 | 70 | 42,521 | (*c*)28,657 |
| 1907.... | 8,779 | 4,795 | (*a*)16,624 | 270 | 50,257 | (*c*)32,969 |
| 1908.... | 7,359 | 5,456 | (*a*)14,925 | 253 | 35,257 | (*c*)35,738 |
| 1909.... | 8,106 | 5,725 | (*a*)14,545 | 246 | 43,165 | (*d*)41,550 |
| 1910.... | (*e*)8,000 | 8,264 | (*a*)17,988 | 180 | 62,607 | 63,000 |
| 1911.... | *Nil.* | 9,502 | (*a*)23,073 | 499 | 32,100 | (*e*)42,300 |
| 1912.... | ..... | ..... | (*a*)21,023 | ..... | 29,152 | 110,881 |

(*a*) Exports. German statistics no longer report production. (*b*) Not reported. (*c*) These statistics collected by THE MINERAL INDUSTRY differ slightly from those reported for the same year by F. J. Fohs in the preceding table. (*d*) Amount mined. (*e*) Estimated.

The following are among those companies in Kentucky and Illinois which produce and will market fluorspar in 1913:

In Illinois: Fairview Fluorspar and Lead Co., Rosiclare Lead and Fluorspar Co., Southern Illinois Fluorspar and Mining Co., A. B. Thomas and J. W. Waggoner. The Illinois production is confined to Pope and Hardin counties.

In Kentucky: Aluminum Ore Co. of America, American Fluorspar Mining Co., Franklin Mining Co., Hoosier Mining Co., Kentucky Fluorspar Co., LaRue Mining Co., Ohio Valley Mining Co., Roberts Fluorspar and Lead Co., The Pygmy Mining Co. and possibly the Western Reserve Mining Co. The Kentucky production now all comes from Crittenden County.

*Kentucky Developments.*—As a result of the improved conditions development work begun in 1911 was greatly extended in 1912 and restricting the output for that year makes possible a greatly increased output in 1913. Only one new property was opened, the Blue Heirs with 4 to 5 ft. of fluorspar. The Widow Hughes mine was further developed by sinking and cross cutting at the 150-, 200- and 250-ft. levels and another will be cut at 300 ft., the vein here is fluorspar with a little lead and calcite, from 2 to 12 ft. wide, averaging 6 to 8 ft. The Keystone mine also on the Columbia fault zone, has shafts 298 and 200 ft. deep; the vein will average over 6 ft. wide and carries 6 per cent. galena. Here are three properties which can be depended upon for large output. The Aluminum Ore Co. of America purchased the Memphis mine and continued improving and developing their property, retimbering the main inclines, the deepest of which is 285 ft. and putting down a series of diamond drill holes to prove the property thoroughly. The Tabb fault

was the scene of renewed activity. The Pygmy mine was developed so as to show four parallel fluorspar veins within 100 ft. of the main fault, all being in the St. Louis limestone side. These veins run from 3 to 5 ft. wide, except that in the fault furthest south which is up to 20 ft. wide; all consist primarily of fluorspar with some calcite, galena, and clay. The Blue and Marble mine (operated by Ohio Valley Mining Co.) shows 4 to 6 ft. of fluorspar, second grade, at the 95-ft. level, with shaft 150 ft. deep. The Hoosier mine produced but little fluorspar, attention being directed chiefly to development of the zinc and sinking and retimbering shafts. The LaRue Mining Co. continued production at the Asbridge mines and are now retimbering the Pogue mine. The Western Reserve is developing the Matthews property with a shaft 150 ft. deep and crosscut. The Matthews mine produced a fair tonnage and attempts are being made to further develop the property with a new 200-ft. shaft and crosscuts. Much useless development is being made at both of the last-named properties through lack of proper geologic guidance prior to development. At the Kentucky mine a new shaft has cut the vein and is now producing much gravel, the vein being 18 ft. wide and of good grade. A fluorspar vein was cut in quartzite at Carrsville. The Babb, Guill and Hudson properties were further developed by the Eagle Fluorspar Co. A 7-ft. vein of fluorspar was cut on the Pierce property near Puckett Spring. Small outputs were noted from the Hodge, Glendale, Harris, Leander and Commodore mines. Altogether much money has been spent in permanent development work with the result that it is now possible to greatly increase Kentucky production; it is urged that the producers have their exploration work keep pace with the exploitation so that the recent depression in output need not be repeated.

*Illinois Developments.*—The Rosiclare mine derives its fluorspar chiefly from the 360-ft. level, while drifts have been started at the 420-ft. level where the vein is 6 ft. wide, so that this also will shortly produce much tonnage. The mine is splendidly equipped and is operated according to the most approved and modern methods. The fluorspar runs from 6 to 23 ft. wide. An electric signaling system for the underground haulage had just been installed to eliminate accident and facilitate movement of the mineral. The mill has been modified in a number of particulars and is now the most complete fluorspar plant in the world. Chief among mill improvements may be mentioned the replacement of the Franier sand pumps by steel bucket elevators, the proportion of water with the mineral being insufficient for the former. The rotary dryer (hot blast) proved impractical and was replaced by steam-heated steel bins, unsatisfactory but still an improvement on the former, the mineral being previously further drained in storage bins. Stirling boilers are being installed. In the re-

cent flooding of the mine by the breaking of the Ohio river, the mine was unwatered in three weeks using three air lifts and an automatic bailing can on the cages; the latter was filled and emptied 2560 times daily. The air lifts removed 2100 gal. per minute, and the bailer somewhat more. A bonus system is successfully used at this mine resulting in material lowering of production costs. The whole plant shows systematic management with ample and proper supervision. This company has also opened the Eureka mine, 2 miles distant which shows 5 ft. of good fluorspar, while 3 miles south of Rosiclare a horizontal replacement deposit is being developed. The Fairview Fluorspar and Lead Company have discontinued operating the lowest level of their main incline which is 503 ft. deep, owing to the inflow of 800 gal. water per minute. The vein where worked alone continues 12 to 14 ft. wide with some calcite. At the Extension shaft, the vein at 165 ft. depth is 18 to 21 ft. wide largely high-grade fluorspar. At the Blue Diggings the shaft is 175 ft. deep with 900 ft. of level run at 140 ft. and the vein white of the best quality, 10 ft. wide between quartzite walls. There has been little change in plant except in the better routing of product by improved haulage methods lessening cost and amount of handling of products. A new concrete boiler house is being erected and automatic stokers installed. Both of the above companies have large tonnages broken in their stopes. The southern Illinois Fluorspar and Mining Co. has devoted its attention to getting a railroad (12 miles now building) to transport its products, an unusually large bedded deposit as well as vertical vein being in sight. The grinding plant has been removed to the mine, and this company hopes to market a large output beginning about July 1. Minor developments are those of companies managed by A. B. Thomas operating the Lee mines and J. W. Waggoner both of which made small shipments.

*Texas.*—White fluorspar is reported 4 miles from Burnet and averages 1 ft. thick.[1] A zinc-bearing fluorite deposit is also reported 7 miles west of Burnet.

Mr. C. S. Nunn, President of the Kentucky Fluorspar Co., in an able brief presented in support of the retention of the present tariff of $3 per ton on fluorspar states clearly certain essential features of the industry, the more important of which are here briefly summarized:

1. The use of fluorspar because of the tariff adds only about 1/2 cent per ton to the cost of production of open-hearth steel over its cost were fluorspar duty-free.

2. It is an industry requiring extensive and costly development equipment. The domestic industry is but little more than 15 years old. After futile attempts to decrease cost of production by increasing equip-

[1] Llano Burnet Folio, U. S. G. S.

ment and tonnage output, it was only with the establishment of the present tariff that the industry began to rise successfully. Investments, aside from property cost since tariff impositions, have exceeded $2,000,000 in the Illinois-Kentucky district, of which more than $300,000 was invested in plant and development at the Rosiclare mine alone.

3. The deposits owing to the irrregular character, size and position of the ore shoots make it impossible to determine quantity or cost of development in advance, and while the cost of development work is similar to that of gold and silver mining the returns on fluorspar are relatively incommeasurate. With increased depth of mines, the increase in cost becomes material. The mines are generally located remote from railway transportation facilities necessitating all equipment being brought to the property at the highest cost of transportation and the product to be shipped at the same disadvantage thus handlage costs vary from 65 cents to $2 per ton.

4. The expense of eliminating by-products and impurities is costly and requires elaborate machinery and skilled labor (the lead recovered barely paying for its removal, yet its deleterious effects in fluxing steel making its elimination essential), and the cost of such treatment being very inconstant.

5. The flooding of mines during wet season, especially by the Ohio river or by local streams causes not only suspension of operation but extensive pumping and recovery costs. Likewise mud runs are the source of much and expensive annoyance.

6. River transportation when the tide is low causes not only partial suspense of shipments but loss of barges by fouling on sand bars. Likewise when river is high or frozen transportation must be suspended.

7. The difficulty of maintaining a sufficient number of skilled mechanics, miners and laborers is a serious problem, it being necessary to insure miners continuous work regardless of water in mines, interruption of transportation, etc. The minimum wage scale in Illinois is now $1.65 per day, ranging from this to $2.50 and as high as $5. English fluorspar labor ranges from 87 1/2 cents to $1 per day.

It follows that fluorspar cannot be produced profitably unless the average selling price of all grades is at least $7 and that of gravel (which constitutes almost 80 per cent. of total production) $6 per ton. Such large mines as the Fairview operated with continuous loss until the tariff became effective, this despite operation on a large scale. The present duty will just about maintain these prices. The profits with these prices, the larger production and more economical distribution of costs, are just sufficient to stimulate increased domestic production, and adjust a regular and adequate supply of domestic fluorspar of desirable quality for the American

consumer. The removal of the tariff while crippling the domestic fluorspar industry, would permit the increase of profit to the foreign producer of about two-thirds of the amount of the tariff. The increase of 1/2 cent in cost of steel production with duty imposed, can have no material effect on the cost to ultimate consumer of steel products.

The cost of production has increased. The increase in cost is due to higher wages and increased depth of mining. Wages have increased 25 to 50 cents per man per ten hours, and hauling 10 to 25 cents per ton. Timber and other supplies are also higher. The range in cost of mining was from 80 cents to $4 per ton. Milling cost was also slightly higher. With proper and economical management the average cost of production should not exceed $3.50 per ton, and the principal items involved should not average higher than the following: Royalty, 0.50; mining, 0.80; milling, 0.60; hauling, $1.12 1/2; loading cars, 0.15; management, 1.24. Under favorable conditions the cost may be as low as $2.25, and in no instance need it exceed $4. The additional cost per ton of ground fluorspar should not exceed $1 for hand picking and grinding and 0.52 for sacking (canvas sacks to be used three times). The cost of development necessarily exceedingly variable, is a prime factor in increasing the cost at some of the mines.

The uses fluorspar or calcium fluoride depend primarily on its chemical composition and its neutral fluxing power. In the first instance, it serves for the production of hydrofluoric acid and hydrofluosilic acid—the latter serving as the electrolytic solution used in the production of electrolytic lead and antimony. As a flux, it is used to reduce the melting heat and assist in elimination of impurities in the manufacture of enamels, glass, and metals, especially in the manufacture of iron and steel. It is to the open-hearth steel process that fully 75 per cent. of the fluorspar consumption must be allotted, to other iron and steel processes 5 per cent. while all other purposes consume the remainder.

In the open hearth process, 8 to 10 lb. of fluorspar per ton of steel produced is about average, this amount of fluorspar being used in connection with 200 lb. of limestone. An increasing use is that in foundry practice where 12 1/2 lb. on No. 1 fluorspar, is used per 42 1/2 lb. of dolomite per ton of charge. This proportion effects a smelt in about half the time were no fluorspar used. With limestone, little or no fluorspar would be used. The effect of the fluorspar is in addition to reducing heat and time of smelt in iron-steel manufacture, to assist elimination of sulphur and phosphorus. An increasing amount of fluorspar is being used in copper metallurgy, while the perfection of the electric steel furnace will mean a material increase in demand for fluorspar.

*Fluorspar.*—The separation of blende and fluorspar was tried by the

Sanders flotation process at Marion, Ky.[1] The crude lead zinc fluorite ore was screened through a 20-mesh screen, treated on Wilfley tables and made three products—lead concentrates, zinc fluorspar middlings, and fluorspar tails. The middlings were agitated in a tank with alum at 85° C., the zinc sulphide being floated off by gas bubbles. Cost of treatment was 34 cents per ton of middlings, and 80 per cent. of the zinc was recovered. This process was fully described in Bulletin 9, Kentucky Geological Survey, 1907, by the present writer. No material changes have since been made in it and it is commercial only when the ore contains 11% or more of zinc. Therefore no commercial separation of zincblende—fluorspar is yet available. However, much ore carrying up to 3% fluorspar is accepted but with a penalty by zinc smelters and when the electric zinc furnace is sucessful fluorspar will be an aid rather than a detriment.

*Fluorine Compounds from Phosphate Industry.*—In this industry the fluorine compounds on treatment with acid, give off objectionable fumes which are rendered harmless by converting them into sodium fluosilicate. The gas issuing from ventilators passes through wooden towers containing quartz fragments. The hydrofluoric acid is transformed into silicon tetrafluoride. This reacts with water to form hydrofluosilicic acid, which dissolves in the water present, forming a solution of 5° Baume. Salt solution is added to form the precipitating sodium fluosilicate.

In Belgium two factories make a specialty of this product, but the combined annual output is only 200 tons. Some of this is exported to Germany. It is used in the enameling industry, in the manufacture of milk-glass, in removing lime from hides, in the electrolytic precipitation of lead and for disinfection purposes.

[1] *Okl. G. S. Bul.*, 9; *Prelim Rept. on Lead and Zinc*, 1912.

# FULLER'S EARTH

The production of fuller's earth in the United States comes chiefly from Florida, although the quality of this material is not such that it is suitable for all the domestic uses. In fact the fuller's earth produced at the various localities in the United States, required extensive trials before it could be definitely established for any particular use. It is for this reason that large quantities of fuller's earth continue to be imported into the United States. In spite of a duty of $1.50 per ton on unmanufactured fuller's earth, this was imported during 1912 to the extent of 1759 long tons, valued at $11,619. The duty on manufactured fuller's earth, namely $3 per ton, did not prevent the importation in addition of 15,303 long tons, valued at $133,718. The year 1912, therefore, is a record for imports both in tonnage and value.

The principal producing state in the United States, was, as heretofore, Florida. Fuller's earth is also produced in Arkansas and Texas. Arkansas was the second largest producer between years 1904 and 1907 and the third largest during 1909–10, and 1911. During these years Georgia was second.

The prices of fuller's earth, as quoted on the market, for average grades was about the same as in 1911; small quantities about 80 cents per hundred pounds, and the average price per short ton at the mines, about $8.75, the latter being somewhat lower than in 1911 when producers reported $9.50 at the mines.

STATISTICS OF FULLER'S EARTH IN THE UNITED STATES.
(In tons of 2000 lb.)

| Year. | Production. | | Imports. | | Years. | Production. | | Imports. | |
|---|---|---|---|---|---|---|---|---|---|
| | Sh. Tons. | Value. | Sh. Tons. | Value. | | Sh. Tons. | Value. | Sh. Tons. | Value. |
| 1901.... | 14,112 | $ 96,835 | 12,061 | $ 80,697 | 1907... | 34,039 | 323,275 | 14,648 | $122,221 |
| 1902 ... | 14,100 | 109,980 | 15,135 | 102,580 | 1908... | 30,517 | 270,685 | 12,279 | 93,413 |
| 1903.... | 20,693 | 190,277 | 17,100 | 120,670 | 1909... | 29,561 | 289,000 | 12,752 | 101,151 |
| 1904.... | 29,480 | 168,500 | 10,221 | 74,000 | 1910... | 30,857 | 277,293 | 16,857 | 132,545 |
| 1905.... | 25,745 | 157,776 | 15,181 | 105,997 | 1911... | 34,668 | 335,350 | 18,224 | 143,594 |
| 1906.... | 28,000 | 237,950 | 14,827 | 108,696 | 1912... | 32,715 | 305,522 | 19,109 | 145,337 |

*Production of Fuller's Earth in Florida during* 1912.—(By E. H. Sellards, State Geologist.) Three companies were actively engaged in mining fuller's earth in Florida during 1912. These were as follows: The Floridin Com-

pany, The Fuller's Earth Company, and the Atlantic Refining Company. The Floridin Company operates two plants, one at Jamieson, and one at Quincy, in Gadsden County. The Fuller's Earth Company plant is located at Midway, in Gadsden County. The Atlantic Refining Company operated as in former years at Ellenton in Manatee County. The actual production of fuller's earth approximates 25,000 short tons.

A detailed description of a number of Florida fuller's earth deposits, were given in Volume XVIII of MINERAL INDUSTRY. Methods of mining are described in the Second Annual Report of the Florida State Geological Survey. The material is sorted, crushed and passed through a drying cylinder and the products stored and ground as needed. The grades of fineness are usually two, namely through 30 and 60 mesh.

*Texas.*—The largest deposits in this state, are in Fayette County near O'Quinn and Muldoon. Some sales were made of material by the Commercial Pulverizer Company, operating in this county.

The Fuller's Earth Company of Somerville, Texas, operated in Burleson County, and was probably the largest producer during 1912. The total production of the state is estimated at 1600 short tons, valued at about $8.60 per short ton. The production in 1911 did not exceed 800 short tons, and in 1910 was estimated at 864 short tons.

The expansion of the petroleum and cottonseed oil industry in Texas makes the production of fuller's earth of importance, and has given a new impetus to the production of the proper quality. A brief description of the location and the deposits of the Somerville Company's plant, is given in MINERAL INDUSTRY, Vol. XX, p. 273.

*Arkansas.*—Statistics of fuller's earth date back to 1895 in the United States. The material was, however, mined as early as 1891 in this state.[1] The production of Arkansas in 1910 was 2563 tons, valued at $29,137. The production of Georgia in 1911 exceeded that of Arkansas. Only two of the five operators were reported as working in 1912.

The area of developed deposits, lies between Hot Springs and Benton, and is about 3 square miles. These deposits were discovered in 1897, and some of the material was used and prepared by the Fairbanks Packing Company, in St. Louis. A plant was erected at the Klondyke station [illegible] the original owner for treating the crude earth. Other operators with [illegible]nts in this area, at the present time, are the Fuller's Earth Union [illegible], of London, England; the Fuller's Earth Co., of Wilmington, Del.; [illegible]red Rossner, of Little Rock, Ark. The original beds were opened [illegible], near Germania and Alexander, and while they had some of the [illegible]es of fuller's earth, were not found successful.

[illegible]anner, "An Early Discovery of Fuller's Earth in Arkansas." *Trans. A. I. M. E.*, July,

In the deposits developed in Arkansas[1] the fuller's earth is derived from basaltic-dikes, and is found in place. Other deposits than these and those of Saxony, are of sedimentary origin. Some of the British deposits belong to the lower green sand formation. The sedimentary deposits of fuller's earth in the United States, belong to the Cretaceous, Tertiary, and Quaternary periods, and are found in Alabama, Arkansas, California, Colorado, Florida, Georgia, Massachusetts, New York, South Carolina, South Dakota, and Texas. The basic dikes occur in shales, the variation of which seems to influence the decomposition of the dikes. The dikes are not often exposed in the original surface, but as the clay of these dikes was found to be fuller's earth, prospecting for other dikes led to their discovery in numbers. The alteration of the dikes has extended downward, in one place 200 ft. vertically. The shaft of this mine is in a hollow, being 160 ft. deep, but it is the deepest mine in the area and in the total depth only two hard masses of dike rock were encountered. On the same dike, 500 ft. from the shaft, unaltered rock was encountered at a depth of 110 ft. The fuller's earth derived from some of these dikes may contain some of the original mica, and may retain the texture of the unaltered dike. The plasticity of the Arkansas earth decreases with increasing depth. The clay is usually jointed, and slickensides are developed along joints on the shale on both walls.

In prospecting, dikes are found by yellowish or reddish-brown color of the clay, the bright red clay being the residual clay from the shales. The residual clay from the dikes, unlike that from the shale, is comparatively free from quartz. Where the shale has a dead sound when struck with a hammer, the dikes have been altered to a greater depth than where the shale is harder.

The Arkansas earth is not used in refining petroleum, and tests made with it for this purpose have not been successful. The success of this earth is chiefly in bleaching cottonseed oil, tallow and stearine. In mining the fuller's earth at these deposits, levels and stopes are formed about 30 ft. apart, and mined until the solid rock is encountered. In the best managed mines the stopes do not reach within 30 ft. of the surface, as this upper clay is stained and very plastic. This clay covering, therefore, prevents surface water getting into the mine, and also the decomposition of the walls. The earth is usually soft enough to require no blasting. The treatment at the mills consists in crushing to 1-in. pieces, and then drying in iron cylinders by means of hot air or steam jacket. It is then finally pulverized and bolted in a similar manner to ordinary flour. In one mill an air-current is used for this separation, without bolting wheels. The finished product

[1] Hugh D. Miser, *Bulletin* 530, *U. S. Geol. Surv.*, 1913, p. 207.

ranges from 80 to 120 mesh, shipped to market in sacks containing 225 to 400 lb. In the bolting process, mica clogs the cloth, and is, therefore, avoided in the crude material. It requires large experience to produce the proper grade of mixing and dilution from a number of stopes.

The operators in Colorado are not producing true fuller's earth, and a material used for silica brick is being shipped from Parkdale.

## Fuller's Earth in Foreign Countries

The foreign fuller's earth is used in the United States, in clarifying oils other than petroleum. The fuller's earth imported into the United States comes chiefly from England. The exports from the United Kingdom are 25000 tons annually. The production in 1911 was 31,454 long tons.

## The Uses of Fuller's Earth

The chemical composition of fuller's earth does not determine its commercial value which depends entirely upon practical tests. The origin of fuller's earth is believed to be from the decomposition of hornblendes and augites, the feldspars forming ordinary clays. The color is generally light brown or gray, but may be white, yellow, greenish-gray, pink or black. The specific gravity is from 1.75 to 2.50. Like ordinary clays it may or may not be plastic. The composition is an aluminum silicate, containing more water and less alumina than other clays, and also containing an appreciable amount of hydrous silica.

The test applied for fuller's earth suitable for petroleum oils, is not as exacting as for vegetable oils. Fuller's earth which was used successfully in California, was not porous and the same was stated in regard to earth from Texas. In Florida also a brown-colored earth of close texture is produced, which decolorizes oil very well.

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# GARNET

The industry is small, garnet being one of the natural abrasives which maintains a place in the industries. As long as it can be cheaply produced, it should hold its position in the abrasive field. Crystal garnet particularly has properties which can hardly be replaced by any other substances for such purposes as abrasive paper. The production is about steady and reached its maximum in 1907. In 1912[1] the production amounted to 4182 short tons valued at $137,800. Abrasives in the form of grindstone and oil-stone, are the basis of a more important industry when the total value of the output per annum is considered. The value of these together, which were produced in the United States, exceeds $1,000,000 annually. The following table shows the production of garnet of the United States in recent years:

PRODUCTION OF GARNET IN THE UNITED STATES.
(In tons of 2000 lb.)

| Year. | Short Tons. | Value. | Value per Ton. | Year. | Short Tons. | Value. | Value per Ton. |
|---|---|---|---|---|---|---|---|
| 1903 | 4,413 | $146,955 | $33.30 | 1908 | 2,530 | $78,090 | $30.86 |
| 1904 | 2,952 | 89,636 | 30.36 | 1909 | 3,802 | 121,700 | 32.01 |
| 1905 | 3,694 | 114,625 | 31.01 | 1910 | 5,297 | 151,700 | 28.64 |
| 1906 | 5,404 | 179,548 | 33.22 | 1911 | 4,285 | 121,759 | 28.44 |
| 1907 | 6,723 | 209,895 | 31.22 | 1912 | 4,182 | 137,800 | 32.95 |

The industry is chiefly centered in New York State, although there is a small production from Carolina and New Hampshire. The North River district in Warren County, New York, furnishes practically the entire production. In 1912 there was a small importation from Spain, but the domestic product is superior. The deposits and geology of the New York deposits is described by Wm. J. Miller.[2]

The demand for garnet in 1912 was strong, and prices were steady. The crushed and graded product, sold uniformly at 6 1/2 cents per pound. The producers were as in previous years, and are given in MINERAL INDUSTRY, Vol. XX, p. 277. The treatment for fine garnet in New Hampshire, is described in MINERAL INDUSTRY, Vol. XX, p. 279.

The use of garnet is chiefly in the manufacture of paper employed in wood and leather finishing trades. The property of gradually

[1] *U. S. Geol. Surv.*
[2] The Garnet Deposits of Warren County, New York, *Econ. Geol.*, Aug., 1912.

wearing away or breaking down, makes the mineral suitable for finishing these materials, and no other mineral is known to possess the required properties.

(By D. H. Newland).—The production of abrasive garnet in the Adirondack region has continued from year to year with little change. The annual total usually is between 4000 and 5000 short tons, now and then slightly exceeding the latter figure. This seems to indicate a fairly stable market which affords the basis for a small and somewhat specialized industry, but which could hardly accommodate any large additional supplies of the mineral, as have been in prospect at different times, without radical readjustment of the present conditions. So far, no permanent or serious competition has developed as the result of mining operations in other sections of the country. For the last few years, however, there has been an importation of Spanish garnet which fills some of the requirements formerly met by the local product. The active mines in the Adirondacks are situated in Essex and Warren Counties. The North River Garnet Co., with mines and mill on Thirteenth lake, Warren County, southwest of North River, is the principal producer and carries on operations more or less continuously throughout the year. The garnet occurs in disseminated crystals in a hard gneissoid hornblende-feldspar rock which has to be crushed and subjected to mechanical separation to recover the mineral, the separation being complicated by the slight difference in the gravity of the garnet and hornblende. The separation is effected mainly by jigs of special design and results in a very clean concentrate, with such variation of sizes as is required for abrasion purposes. The deposit is on the side of a mountain, is mined by open-cut quarry method and by reason of its large size and convenient position admits of great economy in breaking and transporting the rock.

The next most important source of garnet is on Gore mountain, a little west and south of North Creek, and from 4 or 5 miles southeast of the former deposit. The garnet here occurs in a band of dark hornblende gneiss, forming larger crystals than are found anywhere else in the Adirondacks. They measure a foot or even more in maximum diameter. The band of garnet gneiss is relatively narrow and is worked in open pits. The rock is broken down by sledges and the garnet which has been shattered by regional compression is readily picked out of the matrix by hand. These quarries are worked only in the open season. They are operated by H. H. Barton & Son Co. of Philadelphia.

Some production has been made from time to time from Garnet peak, in the town of Minerva, Essex County, about 3 miles from North River, on the Indian Lake road. The garnet is in small crystals, but

plentifully distributed through the rock. In years past, the American Glue Co. has been active at this locality, but made no output in 1913.

The Warren County Garnet Mills, Inc., of Riparius, have recently been active at a locality near Wevertown, south of North Creek. The mineral here is quite different in appearance from that produced in the other mines of this section, being partly granular or compact, rather pale in color, and lacking the tendency to break with smooth surfaces which is characteristic of the crystal garnet. It is also more or less intergrown with a green pyroxene. The material is hand-sorted and prepared for market by grinding to proper size.

Outside of the rather limited area that includes the above-named localities, the only occurrence of garnet that has recently attracted attention as a basis of mining operations is in northern Essex County, a few miles south of Keeseville. The deposits lie on Mt. Bigelow, near the borders, but within the area of anorthosite, the basic igneous rocks that form the central parts of the Adirondacks. They consist of bands, lenses and irregular bunches of granular or seemingly massive garnet which is quite pure, except for inclusions of green pyroxene. They are enclosed directly within the anorthosite. Some of the bands or lenses as seen on the surface are 40 ft. across, nearly solid garnet. They are worked in a rather small way by the American Garnet Co. of New York. A similar deposit is reported from the vicinity of Mt. Pokamoonshine, southwest of Mt. Bigelow.

The production of garnet by the different mines in the Adirondack region amounted last year to 4112 short tons valued at $117,325, compared with 4285 short tons valued at $121,759 in 1911. These totals represent practically the extent of the industry in this country. Imports of abrasive garnet were reported by the Collectors of Customs at Boston and New Orleans, at which points 548 tons valued at $9271 were received in the calendar year. The imports for 1911 were 693 short tons, with an invoice value of $10,526. With the exception of a small shipment of 1200 lb. from Nova Scotia, probably originating in Newfoundland, the garnet was imported from Spain.

## GLASS SAND

The most valuable of the sands, are the glass sand and moulding sand. It is impossible in this volume to go into other sands except by summarizing the production given by the United States Geological Survey as under the table.

It is not possible to give details of the glass industry, the chief raw material of which is glass sand. The itemized statement on page 223 gives production by states:

*Notes on the Glass Industry.*—According to the testimony before the Ways & Means Committee at the Tariff Hearings, the production of window glass in the United States has grown to such an extent that it required only eight months' production by the 4000 pots in this country. To-day less than 1400 hand-operated pots are in blast, and 20 modern plants are idle and 20 modern factories are not operating.

In Belgium the glass industry has nearly doubled since 1880. The industry is of international importance and requires 31,000 operatives in 69 factories. The exports in 1910 were, plate glass, 41,000 tons; window glass, 215,000 tons; bottles, 2500 tons; tableware, 30,500 tons; miscellaneous, 3700 tons. The total value of the output was $16,300,000. Of these exports, plate glass exceeds 90 per cent. of the output. The importance of the industry is also shown by the amount of coal consumed by these factories, which is annually about 1,200,000 tons. In addition, 17,000 tons of soda ash, 109,000 tons of sodium sulphate, 116,000 tons of lime, and 344,000 tons of sand are used. The best grade of sand is that of Fontainebleau, which contains from 0.005 to 0.015 per cent. of ferric oxide. Domestic sand costs about $0.48 per ton at the mines. Ordinary sand with more iron can be obtained for 19 cents per ton. One-half the world's output of plate glass is controlled by a syndicate, to which belong also the nine leading factories in Belgium. The Belgium works supply one-quarter of the world's demand.

The cost of production is said to be as low as 11 cents per square foot of polished plate glass.

The glass industry of Bohemia was particularly prosperous during the year 1912; the exports being $1,218,000 to Germany, $1,725,500 to India, $1,624,000 to England, $2,436,000 to Hamburg, $406,000 to Turkey, $406,000 to Balkan States and $500,000 to the United States. The market is increasing.

Between the German Plate Glass Factories Co. (Deutsche Spiegelglas

Fabriken, Aktiengesellschaft)[1] at Klein Freden and the Glass & Plate Glass Manufactory in Gelsenkirchen-Schalke an agreement has been entered into for exchange of quotas (Quotenaustausch) similar to those

PRODUCTION OF GLASS SAND AND MOULDING SAND. (a)
(Short tons.)

| State. | 1911. | | | | 1912. | | | |
|---|---|---|---|---|---|---|---|---|
| | Glass Sand. | | Molding Sand. | | Glass Sand. | | Molding Sand. | |
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| Alabama | ..... | ..... | 52,766 | $19,432 | ..... | ..... | 51,107 | $25,284 |
| Arkansas | ..... | ..... | 197 | 170 | ..... | ..... | 291 | 291 |
| California | (b) | (b) | 14,153 | 14,757 | ..... | ..... | 41,302 | 22,458 |
| Colorado | ..... | ..... | 7,195 | 2,492 | 9,535 | $8,664 | 17,283 | 5,906 |
| Connecticut | ..... | ..... | 1,335 | 2,465 | ..... | ..... | (b) | ..... |
| Delaware | ..... | ..... | ..... | ..... | ..... | ..... | (b) | ..... |
| Florida | (b) | (b) | 69,745 | 7,978 | ..... | ..... | ..... | ..... |
| Georgia | (b) | (b) | 14,684 | 6,879 | ..... | ..... | (b) | ..... |
| Illinois | 251,907 | $171,978 | 237,359 | 120,690 | 323,467 | 225,434 | 540,728 | 268,521 |
| Indiana | (b) | (b) | 156,993 | 56,777 | 26,040 | ..... | 243,766 | 66,620 |
| Iowa | (b) | (b) | 5,271 | 4,582 | ..... | 10,641 | 4,016 | 3,572 |
| Kansas | (b) | (b) | (b) | (b) | ..... | ..... | ..... | ..... |
| Kentucky | (b) | (b) | 24,222 | 24,426 | (b) | ..... | 29,169 | 27,850 |
| Louisiana | ..... | ..... | ..... | ..... | (b) | ..... | ..... | ..... |
| Maryland | (b) | (b) | 1,422 | 3,307 | ..... | ..... | ..... | ..... |
| Massachusetts | (b) | (b) | 9,629 | 7,899 | (b) | ..... | 18,575 | 9,313 |
| Michigan | (b) | (b) | 68,878 | 17,901 | (b) | ..... | 152,028 | 39,845 |
| Minnesota | ..... | ..... | 27,007 | 23,731 | ..... | ..... | 15,738 | 8,673 |
| Mississippi | (b) | (b) | 8,264 | 3,416 | ..... | ..... | ..... | ..... |
| Missouri | 117,756 | 82,705 | 92,679 | 49,522 | 129,030 | 81,817 | 106,983 | 71,366 |
| Nebraska | ..... | ..... | ..... | ..... | ..... | ..... | 4,097 | 1,826 |
| New Jersey | 91,530 | 68,549 | 715,654 | 392,840 | 102,702 | 79,027 | 459,397 | 279,948 |
| New York | ..... | ..... | 505,256 | 421,503 | (b) | (b) | 584,314 | 469,116 |
| North Carolina | ..... | ..... | 784 | 685 | ..... | ..... | 2,138 | 1,204 |
| North Dakota | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Ohio | 119,991 | 125,576 | 533,163 | 394,145 | 154,527 | 164,462 | 1,186,610 | 649,896 |
| Oklahoma | ..... | ..... | (b) | (b) | ..... | ..... | ..... | ..... |
| Oregon | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Pennsylvania | 478,089 | 668,247 | 657,197 | 451,779 | 427,936 | 517,383 | 792,150 | 627,532 |
| South Carolina | (b) | (b) | (b) | (b) | (b) | ..... | 12,355 | 2,015 |
| South Dakota | ..... | ..... | (b) | (b) | ..... | ..... | ..... | ..... |
| Tennessee | (b) | (b) | 17,156 | 10,703 | (b) | ..... | 36,200 | 15,014 |
| Texas | (b) | (b) | 3,406 | 2,857 | ..... | ..... | 3,135 | 4,050 |
| Utah | ..... | ..... | 405 | 100 | ..... | ..... | ..... | ..... |
| Vermont | ..... | ..... | (b) | (b) | ..... | ..... | (b) | (b) |
| Virginia | (b) | (b) | 41,533 | 18,303 | (b) | ..... | 21,701 | 11,746 |
| Washington | ..... | ..... | (b) | (b) | ..... | ..... | (b) | ..... |
| West Virginia | 268,368 | 313,758 | 2,267 | 1,620 | 244,881 | 287,038 | 28,303 | 24,999 |
| Wisconsin | (b) | (b) | 90,723 | 59,009 | (b) | ..... | 77,026 | 49,599 |
| Others | 211,025 | 112,920 | 17,374 | 12,501 | 47,188 | 55,005 | 56,441 | ..... |
| Total | 1,538,666 | 1,543,733 | 3,376,717 | 2,132,469 | 1,465,386 | 1,430,471 | 4,484,953 | 2,718,398 |

(a) Figures of the U. S. Geol. Survey. (b) Included in others. The production in 1911 was: building sand 24,614,342 tons valued $7,719,286; grinding and polishing sand 938,628 tons valued $521,761; fire sand 213,523 tons valued $158,024; engine sand 1,129,993 tons valued $411,308; furnace sand 458,617 tons valued $189,709; paving sand 1,944,572 tons valued $651,609; total of all sands 40,253,977 tons valued $14,438,500. The productions in 1912 were: Building sand 23,632,157 tons valued $7,904,321; grinding 1,397,667 tons, $667,750; fire sand 455,454 tons, $318,742; engine sand 1,288,486 tons, $428,928; furnace sand 51,446 tons, $27,258; paving sand 1,788,530 tons, $670,680; total sands 38,550,367 tons valued $15,343,613.

prevailing in the syndicate. The Deutsche Speigelglas Aktiengesellschaft is one of the largest exporters of optical glass. The declared value of the optical glass exported from Brunswick to the United States in 1912 was $177,000.

[1] Consul Talbot, J. Albert, Brunswick, *Dly. Consr. and Tr. Rep.*, May 16, 1913.

The glass industry of Silesia, Germany, is shown in the following table:

| | Upper Silesia (Oppeln). | Middle Silesia (Breslau). | Lower Silesia (Liegnitz). | Total. |
|---|---|---|---|---|
| Industries | 7 | 8 | 49 | 64 |
| Furnaces | 14 | 21 | 111 | 146 |
| Pots | 139 | 194 | 1,190 | 1,523 |
| Cisterns | 4 | 5 | 10 | 19 |
| Workmen | 1,200 | 2,490 | 11,135 | 14,825 |

In the county of Rothenburg alone there are 19 factories, 11 of which, with 3000 workmen, are in the city of Weisswasser (population 11,000); in Gorlitz County there are 13, of which 7, with 2100 workmen, are in Penzig (population, 7000). Lower Silesia has an abundance of fine quartz-sand, suitable for glass making. The quartz sand produced in Bavaria in 1910, was 304,463 tons, valued at 756,021 marks; in 1911, 388,724 tons, valued at 712,471 marks.

In Japan the total production of glass and glass-ware, is valued annually at more than $2,000,000. A large importation more than $1,000,000 also supplies the home demand. The manufacture of window glass was successfully opened 3 years ago by the Asahi Glass Co., of Amagasaki, Settsu, which is conducted by the Iwasaki family. The product favorably competes with foreign manufactures, and has contributed to the decrease of importations.

Sweden imports glass sand which amounted in 1912, to 10,144,885 kg.

*Glass Making.*—To-day the making of glass is on the same basis that it has been for a long time and no advances or changes are to be recorded. Machines and mechanical manipulation of glass compel inquiries as to control of melting furnace and composition of raw material, but no literature can be said to exist on the subject. Economies are necessary and are being achieved. In all glass industries the amount of glass melted in order to produce a perfect product involves a good deal of rejected product. In the mechanical process of drawing glass cylinders of salt cake normal glass[1] the per cent. of breakage with the mixture: Sand 1000 lb., crushed limestone 380 lb., salt cake 380 lb., ground coal 18 lb., was 70 per cent. By changing to a batch consisting of sand 1000 lb., limestone 328 lb., soda ash (58 per cent.) 240 lb., salt cake 80 lb., this was materially reduced to perhaps 50 per cent. of breakage. Tests made by this author on the causes of strain, etching and analyzing the glass that etches readily, and finally by determining refractive index lead to the conclusion that the defects, strain, etc., are caused in

[1] Robert L. Frink, Columbus, Ohio., *Eighth Intl. Congr. Appl. Chem.*, Vol. V.

the melting and handling of the glass prior to the time that it reaches the solid state. The working out of a simple method of control by determining refractive index is recommended by the author. In America unlike in the foreign industry, capitalists do not depend upon the research laboratory but rather on the published facts and theories protected by patents, law and jurisdiction. They shun investment when the method does not give the desired result, and an investigation of patents issued in the United States soon reveals the fact that there is substantially no understanding of the principles governing the properties of glass, nor of the reactions controlling its composition. While much improvement is made in developing patents and processes, the manufacturers have the means at hand to carry on experiments on the lines indicated, whereas universities and other laboratories are not likely to go to the expense of running full size furnaces which will represent the manufacturing conditions.

The commerical classification of glass is, first, plate-glass, second, window-glass, third, flint-glass and fourth, bottle-glass.

The following tables show compositions of various grades:[1]

ANALYSES OF WINDOW GLASS.

| | French (Dumas). | English (Dumas). | Chance's (Cooper). | Russian (Benrath). |
|---|---|---|---|---|
| Alumina | 7.60 | 69.00 | 71.40 | 71.27 |
| Silicia | 68.00 | 11.10 | 15.00 | 20.10 |
| Soda | 10.10 | 12.50 | 12.40 | 8.14 |
| Lime | 14.30 | 7.40 | 0.60 | ..... |

ANALYSES OF LEAD GLASS.

| Glass | Analyst. | Silica. | Soda. | Potash. | Lime. | Lead. | Iron. | Alumina. |
|---|---|---|---|---|---|---|---|---|
| English crystal | Faraday | 51.93 | ..... | 13.67 | ..... | 33.28 | ..... | ..... |
| English crystal | Berthier | 59.20 | ..... | 9.00 | ..... | 28.20 | 0.40 | ..... |
| French crystal | Sauerwein | 48.10 | ..... | 12.50 | 0.60 | 38.00 | 0.50 | ..... |
| French crystal | Benrath | 50.18 | ..... | 11.62 | ..... | 38.11 | 1.30 | 1.30 |
| American crystal | Fletcher | 53.98 | 6.71 | 7.60 | ..... | 29.78 | 1.93 | 1.93 |
| American crystal | Fletcher | 54.12 | 5.58 | 7.98 | ..... | 31.27 | 1.05 | 1.05 |

ANALYSES OF LIME GLASS.

| Glass. | Analyst. | Silica. | Soda. | Potash. | Lime. | Magnesia. | Manganese. | Iron. | Alumina. | Baryta |
|---|---|---|---|---|---|---|---|---|---|---|
| French | Pelouze | 72.10 | 12.40 | ..... | 15.50 | ..... | ..... | ..... | ..... | ..... |
| French tubes | Berthier | 69.20 | 3.00 | 15.80 | 7.60 | 2.00 | ..... | 0.50 | 1.20 | ..... |
| Bohemian | Rowney | 73.13 | 3.07 | 11.49 | 10.43 | 0.26 | 0.46 | 0.13 | 0.30 | ..... |
| American | De Brunner | 71.92 | 14.55 | ..... | 5.14 | 2.04 | ..... | ..... | 6.22 | ..... |
| American | Henrivaux | 70.40 | 9.13 | 8.66 | 10.00 | ..... | 0.50 | 0.02 | 0.99 | ..... |
| American | Benrath | 67.10 | 10.30 | 4.20 | 5.10 | ..... | ..... | 0.10 | 0.30 | 11.90 |

[1] Taken from the Elements of Glass and Glass-making, Benj. Bizer, out of print.

ANALYSES OF BOTTLE GLASS.

| Kind of Glass. | Analysts. | Silica. | Soda. | Potash. | Lime. | Manganese. | Sesqui Oxide of Iron. | Alumina. | Magnesia. |
|---|---|---|---|---|---|---|---|---|---|
| French, Sauvigny | Berthier | 60.00 | 3.10 | 3.10 | 22.30 | 1.20 | 4.00 | 8.00 | ..... |
| St. Etienne | Berthier | 60.40 | 3.20 | 3.20 | 20.70 | ..... | 3.80 | 10.40 | ..... |
| Epinac | Berthier | 59.60 | ..... | 3.20 | 18.00 | 0.40 | 4.40 | 6.80 | 7.00 |
| Sevres | Dumas | 53.55 | ..... | 5.48 | 29.22 | ..... | 5.74 | 6.01 | ..... |
| Clichy | Dumas | 45.60 | ..... | 6.10 | 28.10 | ..... | 6.20 | 14.00 | ..... |
| Bohemian, Champagne | Maumeno | 58.40 | 9.90 | 1.80 | 18.60 | ..... | 8.90 | 2.10 | ..... |
| Champagne | Maumeno | 62.21 | 5.69 | 1.91 | 22.93 | ..... | 6.10 | 1.16 | ..... |
| German | Benrath | 69.82 | 18.28 | 1.50 | 7.82 | ..... | 2.58 | 2.58 | ..... |
| German | Benrath | 62.78 | 19.14 | 11.24 | 6.11 | ..... | 0.73 | 0.73 | ..... |
| Russian | Benrath | 65.77 | 11.75 | 11.75 | 16.58 | ..... | 5.90 | 5.90 | ..... |
| Russian | Benrath | 68.38 | 19.03 | 19.03 | 10.19 | ..... | 2.40 | 2.40 | ..... |

ANALYSES OF PLATE GLASS.

| | French. | | English. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | St. Gobain. Peligot. | French. Dumas. | Chances. Benrath. | British Plate Glass Co. / London and Thames. Mayer & Brazier. | | Belgian. Charleroi. Benrath. | German. Jaeckel. | Hanoverian. Emmerling. | Venetian. Berthier. |
| Silica | 73.00 | 75.90 | 70.71 | 77.36 | 78.68 | 73.31 | 72.31 | 73.79 | 68.6 |
| Soda | 11.50 | 17.50 | 13.25 | 13.06 | 11.36 | 13.00 | 11.42 | 13.94 | 8.10 |
| Potash | ..... | ..... | ..... | 3.01 | 1.34 | ..... | ..... | 0.60 | 6.90 |
| Lime | 15.50 | 3.80 | 13.38 | 5.31 | 6.09 | 13.34 | 14.96 | 8.61 | 11.00 |
| Magnesia | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 0.12 | 2.10 |
| Manganese | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 0.32 | 0.10 |
| Sesqui-oxide of Iron | ..... | ..... | 1.92 | 0.91 | trace | 0.83 | ..... | 0.68 | 0.20 |
| Alumina | ..... | ..... | ..... | trace | 2.68 | ..... | 0.81 | 0.58 | 1.20 |

*Glass-sand.*—The requirements of glass-sand according to the prevailing opinion of glass-makers,[1] are that the grains of sand shall be sharp. The reason for this is that rounded and smooth grains do not leave spaces enough for the heat to pass through, and the tendency of rounded grains is to settle in the melting pot. Several prominent glass plants in the Mississippi Valley, however, are making fine flint wares, and also ordinary grades, with the use of sand with rounded grains.

The most desirable size of grain is also a disputed point, but the smaller grain requires less fuel and will melt more quickly. The prevailing opinion in this matter, is that the grains shall not be larger than 30 mesh, nor smaller than 120 mesh. A somewhat wider range can be used, provided grains are uniform in size. The finer grains produce less glass

[1] Frank Buttram, Bulletin No. 10, Oklahoma Geological Survey.

per bulk of sand, and the larger grains produce less glass per day, on account of difficulty in fusing.

Ordinary deposits of sand, as this is not a very valuable material, average price in 1910 in the United States being $1.04 per ton, should be 20 in. in thickness and have an area of 25 acres in order to warrant the erection of a mill.

The amount of lime required for various glasses is as follows:

Window-glass 8 to 15 per cent.; plate-glass 3 1/2 to 16 per cent.; bottle-glass 6 to 30 per cent.; lime-flint-glass, 5 to 16 per cent.

The analysis of various sand-beds of Oklahoma are given in Bulletin 10, of the Oklahoma Geological Survey.

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# GOLD AND SILVER

The gold production of the world in 1912 exceeded that of any previous year, the increase over 1911 having been $10,000,000, or 2.2 per cent. This increase was due entirely to the large gain in the Transvaal, which was approximately $23,000,000. All the other African mines—

GOLD PRODUCTION OF THE WORLD. (a)

| Countries. | 1910. | | | 1911. | | | 1912. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Oz. Fine. | Kilograms | Value. | Oz. Fine. | Kilograms | Value. | Oz. Fine. | Kilograms | Value. |
| America, North: | | | | | | | | | |
| United States... | (b)4,657,017 | 144,853 | $96,269,100 | (b)4,687,053 | 145,777 | $96,890,000 | (b)4,437,561 | 138,008 | $91,685,13 |
| Canada..... | (a) 493,751 | 15,357 | 10,205,835 | (a) 473,201 | 14,719 | 9,781,077 | (a) 607,617 | 18,897 | 12,559,44 |
| Mexico..... | (b)1,093,053 | 33,998 | 24,484,372 | (g)1,412,483 | 43,933 | 29,196,026 | (g)1,096,058 | 34,092 | 22,655,51 |
| Central America. | (b) 131,287 | 4,083 | 2,713,700 | (b) 165,457 | 5,146 | 3,420,000 | (e) 175,000 | 5,442 | 3,617,25 |
| America, South: | | | | | | | | | |
| Argentina..... | (b) 8,372 | 260 | 173,061 | (b) 13,979 | 435 | 289,000 | (e) 14,467 | 450 | 299,04 |
| Bolivia..... | 1,511 | 47 | 31,232 | (a) 1,082 | 33 | 22,370 | (a) 1,117 | 35 | 23,09 |
| Brazil..... | (g) 94,566 | 2,972 | 1,954,674 | (g) 109,949 | 3,420 | 2,272,631 | (g) 102,380 | 3,184 | 2,116,20 |
| Chile..... | (b) 22,429 | 698 | 463,600 | (b) 17,661 | 549 | 365,058 | (e) 19,290 | 600 | 398,72 |
| Colombia..... | 163,038 | 5,071 | 3,370,000 | (b) 153,241 | 4,776 | 3,167,800 | (e) 160,750 | 5,000 | 3,322,70 |
| Ecuador ..... | (g) 12,054 | 375 | 249,179 | (b) 13,389 | 416 | 276,800 | (e) 12,860 | 400 | 265,87 |
| Guiana, British. | (g) 57,002 | 1,773 | 1,178,645 | (a) 46,387 | 1,443 | 958,819 | (a) 42,563 | 1,324 | 879,77 |
| Guiana, Dutch.. | (b) 38,744 | 1,193 | 792,690 | (a) 36,500 | 1,140 | 754,450 | (a) 13,948 | 434 | 288,41 |
| Guiana, French.. | (a) 108,851 | 3,386 | 2,249,940 | (a) 147,536 | 4,589 | 3,049,569 | (e) 144,675 | 4,500 | 2,990,43 |
| Peru..... | (a) 22,762 | 708 | 470,505 | (b) 22,055 | 686 | 455,900 | 23,823 | 741 | 492,42 |
| Uruguay..... | (a) 4,433 | 138 | 91,642 | (b) 3,422 | 106 | 70,600 | (e) 3,215 | 100 | 66,45 |
| Venezuela..... | (g) 16,472 | 512 | 340,512 | (a) 16,238 | 522 | 335,650 | (e) 17,682 | 550 | 365,49 |
| Europe: | | | | | | | | | |
| Austria..... | 5,739 | 178 | 118,895 | (a) 6,591 | 205 | 134,840 | (e) 6,430 | 200 | 132,90 |
| France..... | (a) 70,392 | 2,190 | 1,455,027 | (a) 87,641 | 2,726 | 1,812,077 | (e) 96,450 | 3,000 | 1,993,62 |
| Hungary..... | (a) 97,824 | 3,043 | 2,022,032 | (a) 102,687 | 3,194 | 2,125,241 | (e) 102,880 | 3,200 | 2,126,52 |
| Germany..... | (a) 148,697 | 4,625 | 3,073,568 | (a) 159,692 | 4,967 | 3,300,845 | (e) 160,750 | 5,000 | 3,322,70 |
| Italy..... | (a) 485 | 15 | 10,047 | (a) 829 | 26 | 17,119 | (e) 804 | 25 | 16,61 |
| Russia..... | (e)1,716,722 | 53,396 | 35,566,045 | 1,465,693 | 45,589 | 30,295,881 | (a)1,395,882 | 43,562 | 28,852,88 |
| Portugal..... | (a) 129 | 4 | 2,658 | (a) 129 | 4 | 2,658 | (a) 129 | 4 | 2,65 |
| Sweden..... | 96 | 3 | 1,990 | (a) 354 | 11 | 7,310 | (a) 997 | 31 | 19,60 |
| Turkey..... | (b) 290 | 9 | 6,000 | (b) 1,447 | 45 | 29,905 | (e) 322 | 10 | 6,64 |
| United Kingdom | (a) 1,914 | 60 | 39,562 | (a) 354 | 11 | 7,310 | (e) 14 | ½ | 28 |
| Africa: | | | | | | | | | |
| Congo..... | (a) 24,273 | 755 | 501,728 | 29,128 | 906 | 602,073 | (e) 30,237 | 940 | 625,00 |
| Madagascar..... | (g) 104,002 | 3,235 | 2,14,9721 | (a) 91,627 | 2,850 | 1,893,940 | (e) 96,760 | 3,009 | 2,000,00 |
| Rhodesia..... | 609,956 | 18,971 | 12,481,457 | (a) 628,521 | 19,547 | 12,989,763 | (a) 642,807 | 19,991 | 13,286,82 |
| Transvaal..... | 7,526,860 | 234,112 | 155,528,432 | (a)8,020,422 | 249,469 | 165,782,032 | (a)9,131,558 | 283,991 | 188,749,31 |
| West Coast..... | (a) 177,750 | 5,529 | 3,674,087 | (a) 251,968 | 7,836 | 5,208,183 | (a) 342,045 | 10,638 | 7,070,07 |
| Asia: | | | | | | | | | |
| Borneo, British. | (e) 41,751 | 1,298 | 863,070 | (a) 71,807 | 2,233 | 1,484,250 | (e) 80,375 | 2,500 | 1,661,35 |
| China..... | (g) 176,960 | 5,504 | 3,658,091 | (b) 160,344 | 4,987 | 3,314,600 | (e) 160,750 | 5,000 | 3,322,70 |
| E. Indies, Dutch | (b) 163,852 | 5,097 | 3,387,131 | (b) 163,852 | 5,096 | 3,387,100 | (e) 160,750 | 5,000 | 3,322,70 |
| India..... | (a) 518,010 | 16,110 | 10,705,739 | (a) 526,622 | 16,380 | 10,899,756 | (a) 534,543 | 16,627 | 11,063,69 |
| Formosa..... | (a) 53,164 | 1,653 | 1,098,900 | 53,273 | 1,657 | 1,100,877 | (e) 53,048 | 1,650 | 1,096,49 |
| n..... | (a) 140,434 | 4,368 | 2,902,777 | (a) 150,541 | 4,682 | 3,111,675 | (e) 160,000 | 4,976 | 3,307,20 |
| ..... | (b) 212,808 | 6,619 | 4,399,137 | (g) 315,422 | 9,810 | 6,519,773 | (g) 243,922 | 7,586 | 5,041,86 |
| es.... | (b) 15,296 | 476 | 316,188 | (a) 8,414 | 262 | 174,017 | (a) 12,866 | 400 | 265,94 |
| (c)... | (a), 108,065 | 96,661 | 64,243,704 | (a)2,877,295 | 89,484 | 58,322,770 | (a)2,636,391 | 81,992 | 54,492,40 |
| tries. | (e) 25,000 | 778 | 516,750 | (e) 25,000 | 778 | 516,750 | (e) 25,000 | 778 | 516,75 |
| .... | 21,865,781 | 680,013 | $453,766,523 | 22,519,286 | 700,445 | $464,346,495 | 22,948,716 | 713,867 | $474,322,664 |

cial statistics of the country. (b) United States Mint Report. (c) Six States and New
e) Estimated. (g) Exports.

Rhodesia and West Africa especially—showed gains sufficient to offset losses in the United States, in Russia and in Mexico. The mines of Australasia also continued the decrease in production which has now extended over several years. The Asiatic mines generally increased their production, especially those of the Kolar district, in British India. Details concerning the Transvaal, Rhodesia, the more important districts of the United States, Mexico and Canada, are given in the paragraphs which follow.

In Russia the decline was due to labor troubles and scarcity of water at many of the important placers, notably those of the Lena Gold Mining Co., which has for two or three years been the largest producer in Siberia. The decline in Mexico was due mainly to the disturbed condition of the country.

SILVER PRODUCTION OF THE WORLD.

| Country. | 1911. | | | 1912. | | |
|---|---|---|---|---|---|---|
| | Oz. Fine. | Kilograms. | Value. (*d*) | Oz. Fine. | Kilograms. | Value. (*d*) |
| North America: | | | | | | |
| United States | (*b*) 60,399,400 | 1,878,675 | $32,192,883 | (*b*) 62,369,903 | 1,939,966 | $37,920,899 |
| Canada | (*a*) 32,559,044 | 1,012,723 | 17,355,272 | (*a*) 31,931,710 | 993,210 | 19,425,656 |
| Mexico | (*g*) 87,078,764 | 2,708,456 | 42,842,752 | (*g*) 82,506,963 | 2,566,313 | 47,605,160 |
| Central America | (*b*) 1,211,747 | 37,690 | 654,300 | (*e*) 1,733,142 | 53,908 | 1,000,000 |
| South America: | | | | | | |
| Argentina | (*b*) 203,111 | 6,318 | 109,700 | (*e*) 208,975 | 6,500 | 120,575 |
| Bolivia | (*a*) 4,111,985 | 127,900 | 2,023,378 | (*a*) 3,984,639 | 123,939 | 2,299,068 |
| Chile | (*g*) 853,036 | 26,533 | 419,746 | (*e*) 868,050 | 27,000 | 500,850 |
| Colombia | (*b*) 817,431 | 25,425 | 441,400 | (*e*) 835,900 | 26,000 | 422,300 |
| Ecuador | (*b*) 22,642 | 704 | 12,200 | (*e*) 22,505 | 700 | 12,985 |
| Peru | (*a*) 9,303,663 | 289,383 | 4,578,023 | (*e*) 9,323,500 | 290,000 | 5,379,500 |
| Europe: | | | | | | |
| Austria | (*a*) 1,615,345 | 50,244 | 884,203 | (*e*) 1,607,500 | 50,000 | 927,500 |
| Belgium(*f*) | (*a*) 8,124,948 | 252,720 | 5,150,929 | (*a*) 9,000,875 | 279,965 | 4,993,351 |
| France | (*a*) 1,159,956 | 47,277 | 829,900 | (*e*) 1,446,750 | 45,000 | 834,750 |
| Germany | (*a*) 14,132,805 | 439,580 | 6,953,400 | (*e*) 14,146,000 | 440,000 | 8,162,000 |
| Greece | (*b*) 882,796 | 27,459 | 476,700 | (*e*) 803,750 | 25,000 | 463,750 |
| Hungary | (*a*) 347,413 | 10,806 | 184,181 | (*e*) 353,650 | 11,000 | 204 050 |
| Italy | (*a*) 424,219 | 13,195 | 208,744 | (*e*) 417,950 | 13,000 | 241,150 |
| Norway | (*a*) 336,546 | 10,468 | 165,581 | 302,210 | 9,400 | 174,370 |
| Portugal | (*a*) 117,894 | 3,667 | 58,004 | (*a*) 149,369 | 4,646 | 86,183 |
| Russia | (*b*) 477,140 | 14,841 | 257,700 | (*e*) 321,500 | 10,000 | 185,500 |
| Spain | (*a*) 3,539,136 | 110,082 | 1,741,255 | (*e*) 4,179,500 | 130,000 | 2,411,500 |
| Sweden | (*a*) 41,441 | 1,289 | 22,772 | (*a*) 30,928 | 962 | 17,845 |
| Turkey | (*b*) 1,717,896 | 53,434 | 927,700 | (*e*) 964,500 | 30,000 | 556,500 |
| United Kingdom | (*a*) 493,720 | 15,356 | 242,910 | (*e*) 482,250 | 15,000 | 278,250 |
| Asia: | | | | | | |
| Dutch Indies | (*b*) 465,980 | 14,494 | 251,600 | (*e*) 462,960 | 14,400 | 267,120 |
| Formosa | (*a*) 59,442 | 1,852 | 31,746 | (*e*) 61,085 | 1,900 | 35,245 |
| Japan | (*a*) 4,438,037 | 138,042 | 2,365,473 | (*e*) 4,501,000 | 140,000 | 2,597,000 |
| Africa | (*b*) 1,064,050 | 33,096 | 574,600 | (*e*) 1,125,250 | 35,000 | 649,250 |
| Australasia | (*a*) 17,109,650 | 532,182 | 9,102,362 | (*a*) 16,112,054 | 501,152 | 9,712,935 |
| Other countries | (*e*) 725,000 | 22,555 | 356,820 | (*e*) 725,000 | 22,555 | 356,820 |
| Total | 254,214,237 | 7,906,446 | $131,408,234 | 250,979,368 | 7,806,516 | $147,902,008 |

(*a*) Official statistics of the country. (*b*) United States Mint Report. (*e*) Estimated. (*d*) The value of silver unless specifically reported in the official statistics of the country is taken as $0.492 in 1911, and $0.577 in 1912. (London quotations.) (*f*) Largely from imported ores and may duplicate production to some extent. (*g*) Exports.

At the present time, the African continent is the leading gold producer of the world, owing to the extraordinary output of the Transvaal. Africa furnished 45.1 per cent. of the total gold production in 1912, the Transvaal

alone reporting 40.1 per cent. of the total. The North American continent comes second in the list with 27.4 per cent. of the total, the United States alone supplying 19.5 per cent. The Australasian production which, at one time, constituted nearly one-third of the world's total, was last year only 12.1 per cent.

In 1912, as in the preceding year, we cannot report the opening of any new districts of the first importance. Minor discoveries have been made here and there, but no large new districts like the Yukon have been discovered or opened. The world is coming to be so thoroughly explored that there are only a few regions in which we can look for new accessions to our gold producers. The Congo Free State in Africa, some parts of South America, and the provinces of Manchuria and Mongolia, in China, are regions in which there are still opportunity for much prospecting. Some Canadian explorers have thought that the Mackenzie country in the far North of Canada may develop a second Yukon, but there are so far no reliable data on which to base such an opinion.

Great as has been the increase in gold production, it has hardly kept pace with the demand for the metal in commerce, and as a basis for the world's credit. At the close of the year was recorded an urgent demand for gold from the leading financial centers of Europe. The imports of gold into the United States are largely from Mexico, Central and South America, in the form of bullion; while some comes also from Australia and Japan, chiefly in copper and other bullion to be refined.

Leading authorities are agreed that the present rate of increase in gold output cannot continue much longer, if, indeed, the high point in annual production has not already been reached.

GOLD AND SILVER PRODUCTION OF THE WORLD, 1493–1850.

According to Dr. Adolph Soetbeer.

| Period. | Estimated Production in Kilograms. | | Ratio of Silver to Gold. Weight. | Ratio of Gold to Silver. Value. | Period. | Estimated Production in Kilograms. | | Ratio of Silver to Gold. Weight. | Ratio of Gold to Silver. Value. |
|---|---|---|---|---|---|---|---|---|---|
| | Gold. | Silver. | | | | Gold. | Silver. | | |
| 1493–1520 | 162,400 | 1,316,000 | 8.1 | 10.75 | 1701–1720 | 256,400 | 7,112,000 | 27.7 | 15.21 |
| 1521–1544 | 171,840 | 2,164,800 | 12.6 | 11.25 | 1721–1740 | 381,600 | 8,624,000 | 22.6 | 15.08 |
| 1545–1560 | 136,160 | 4,985,600 | 36.6 | 11.30 | 1740–1760 | 492,200 | 10,662,900 | 21.7 | 14.75 |
| 1561–1580 | 136,800 | 5,990,000 | 43.8 | 11.50 | 1761–1780 | 414,100 | 13,054,800 | 31.5 | 14.73 |
| 1581–1600 | 147,600 | 8,378,000 | 56.8 | 11.80 | 1781–1800 | 355,800 | 17,581,200 | 49.4 | 15.09 |
| 1601–1620 | 170,400 | 8,458,000 | 49.6 | 12.25 | 1801–1810 | 177,780 | 8,941,500 | 50.3 | 15.61 |
| 1621–1640 | 166,000 | 7,872,000 | 47.4 | 14.00 | 1811–1820 | 114,450 | 5,407,700 | 47.2 | 15.51 |
| 1641–1660 | 175,400 | 7,326,000 | 41.8 | 14.50 | 1821–1830 | 142,160 | 4,605,600 | 32.4 | 15.80 |
| 1661–1680 | 185,200 | 6,740,000 | 36.4 | 15.00 | 1831–1840 | 202,890 | 5,964,500 | 29.4 | 15.75 |
| 1681–1700 | 215,300 | 6,838,000 | 31.8 | 14.97 | 1841–1850 | 547,590 | 7,804,150 | 14.3 | 15.83 |

GOLD PRODUCTION OF THE WORLD, 1851–1912.

| Year. | Value | Year. | Value. | Year. | Value. | Year. | Value. |
|---|---|---|---|---|---|---|---|
| 1851... | $67,600,000 | 1867... | $104,000,000 | 1883... | $95,400,000 | 1899... | $311,505,947 |
| 1852... | 132,800,000 | 1868... | 109,700,000 | 1884... | 101,700,000 | 1900... | 258,829,703 |
| 1853... | 155,500,000 | 1869... | 106,200,000 | 1885... | 108,400,000 | 1901... | 260,877,429 |
| 1854... | 127,500,000 | 1870... | 106,900,000 | 1886... | 106,000,000 | 1902... | 298,812,493 |
| 1855... | 135,100,000 | 1871... | 107,000,000 | 1887... | 105,775,000 | 1903... | 329,475,401 |
| 1856... | 147,600,000 | 1872... | 99,600,000 | 1888... | 110,197,000 | 1904... | 349,088,293 |
| 1857... | 133,300,000 | 1873... | 96,200,000 | 1889 .. | 123,489,000 | 1905... | 378,411,754 |
| 1858... | 124,700,000 | 1874... | 90,800,000 | 1890... | 118,848,700 | 1906... | 405,551,022 |
| 1859... | 124,900,000 | 1875... | 97,500,000 | 1891 .. | 130,650,000 | 1907... | 416,101,396 |
| 1860... | 119,300,000 | 1876 .. | 103,700,000 | 1892... | 146,292,600 | 1908... | 443,355,856 |
| 1861... | 113,800,000 | 1877... | 114,000,000 | 1893... | 158,437,551 | 1909... | 458,424,058 |
| 1862... | 107,800,000 | 1878... | 119,000,000 | 1894... | 182,509,283 | 1910... | 453,766,523 |
| 1863... | 107,000,000 | 1879... | 109,000,000 | 1895... | 198,995,741 | 1911... | 464,346,495 |
| 1864... | 113,000,000 | 1880... | 106,600,000 | 1896... | 211,242,081 | 1912... | 474,322,664 |
| 1865... | 120,200,000 | 1881... | 103,102,000 | 1897... | 237,833,984 | ..... | ..... |
| 1866... | 121,000,000 | 1882... | 102,000,000 | 1898... | 287,327,833 | ..... | ..... |

SILVER PRODUCTION OF THE WORLD, 1856–1912.

| Year. | Kilograms. | Year. | Kilograms. | Year. | Kilograms. | Year. | Kilograms. |
|---|---|---|---|---|---|---|---|
| 1856–1860 . | 4,534,950 | 1883.... | 2,746,123 | 1894..... | 5,205,065 | 1905..... | 5,638,183 |
| 1861–1865 . | 5,505,575 | 1884.... | 2,788,727 | 1895..... | 5,667,691 | 1906..... | 5,683,947 |
| 1866–1870.. | 6,695,425 | 1885.... | 2,993,805 | 1896..... | 5,496,178 | 1907..... | 5,704,083 |
| 1871–1875 . | 9,847,125 | 1886.... | 2,902,471 | 1897..... | 5,663,304 | 1908..... | 6,612,304 |
| 1876..... | 2,323,729 | 1887.... | 2,990,398 | 1898..... | 5,575,336 | 1909..... | 7,069,656 |
| 1877..... | 2,388,612 | 1888.... | 3,385,606 | 1899..... | 5,529,024 | 1910..... | 471,663 |
| 1878..... | 2,551,364 | 1889.... | 3,901,809 | 1900..... | 5,599,216 | 1911..... | 7,906,446 |
| 1879..... | 2,507,507 | 1890.... | 4,180,532 | 1901..... | 5,438,443 | 1912..... | 7,806,516 |
| 1880..... | 2,499,998 | 1891.... | 4,479,649 | 1902..... | 5,121,469 | ..... | ..... |
| 1881..... | 2,592,639 | 1892.... | 4,985,855 | 1903..... | 5,386,044 | ..... | ..... |
| 1882..... | 2,769,065 | 1893.... | 5,339,746 | 1904..... | 5,669,124 | ..... | ..... |

## THE SILVER MARKET.

The silver market throughout 1912 was strong and advancing, with only occasional slight reactions. The average monthly prices advanced from 25.887d. in London and 56.260 cents in New York in January to 29.320d. in London and 63.365 cents in New York in December; gains of 3.433d. in London and 7.105 cents in New York. The average prices for 1912 were 28.042d. in London and 60.835 cents in New York; comparing with 24.592d. in London and 53.304 cents in New York for 1911. the table below shows the monthly averages in New York and London for ten years past.

London continues to be the chief silver market of the world and the basing point of prices. This is chiefly due to its control of the trade with the East, which has not been shaken by any changes in the courses of trade. The market through the year was supported and advanced by the heavy demand from the East,which is the largest purchaser of silver. India increased its takings of silver, notwithstanding its heavy buying of gold. The larger exports of silver from London to India were mainly on private account, the Indian government taking no silver for coinage until

late in the year. The speculative interest in silver, which was so prominent in London in 1911, was not much in evidence in 1912. It is suspected that the Indian speculators took advantage of the advancing prices to unload at least a part of their holdings; if so, it was done very quietly, and the advance was not checked.

AVERAGE PRICE OF BAR SILVER IN LONDON, 1833–1912.
(In pence per standard ounce, 0.925 fine.)

| Year. | Pence. | Year. | Pence. | Year. | Pence. | Year. | Pence. | Year. | Pence. | Year. | Pence. | Year. | Pence. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1833. | 59.1875 | 1843 | 59.1875 | 1853 | 61.5000 | 1863 | 61.3750 | 1873 | 59.2500 | 1883 | 50.5625 | 1893 | 35.6250 |
| 1834. | 59.9375 | 1844 | 59.5000 | 1854 | 61.5000 | 1864 | 61.3750 | 1874 | 58.3125 | 1884 | 50.6250 | 1894 | 28.9375 |
| 1835. | 59.6875 | 1845 | 59.2500 | 1855 | 61.3125 | 1865 | 61.0625 | 1875 | 56.8750 | 1885 | 48.6250 | 1895 | 29.8750 |
| 1836. | 60.0000 | 1846 | 59.3125 | 1856 | 61.3125 | 1866 | 61.1250 | 1876 | 52.7500 | 1886 | 45.3750 | 1896 | 30.7500 |
| 1837. | 59.5625 | 1847 | 59.6875 | 1857 | 61.7500 | 1867 | 60.5625 | 1877 | 54.8125 | 1887 | 44.6250 | 1897 | 27.5625 |
| 1838. | 59.5000 | 1848 | 59.5000 | 1858 | 61.3125 | 1868 | 60.5000 | 1878 | 52.5625 | 1888 | 42.8750 | 1898 | 26.4375 |
| 1839. | 60.3750 | 1849 | 59.7500 | 1859 | 62.0625 | 1869 | 60.4375 | 1879 | 51.2500 | 1889 | 42.6875 | 1899 | 27.4375 |
| 1840. | 60.3750 | 1850 | 60.0625 | 1860 | 61.6875 | 1870 | 60.5625 | 1880 | 52.2500 | 1890 | 47.6875 | 1900 | 28.2500 |
| 1841. | 60.0625 | 1851 | 61.0000 | 1861 | 60.8125 | 1871 | 60.5000 | 1881 | 51.6875 | 1891 | 45.0625 | 1901 | 27.1875 |
| 1842. | 59.4375 | 1852 | 60.5000 | 1862 | 61.4375 | 1872 | 60.3125 | 1882 | 51.6250 | 1892 | 39.8125 | 1902 | 24.0900 |

| Year. | Jan. | Feb. | Mar. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1903.... | 21.98 | 22.11 | 22.49 | 23.38 | 24.89 | 24.29 | 24.86 | 25.63 | 26.75 | 27.89 | 27.01 | 25.73 | 24.75 |
| 1904.... | 26.423 | 26.665 | 26.164 | 24.974 | 25.578 | 25.644 | 26.760 | 26.591 | 26.591 | 26.349 | 26.760 | 27.930 | 26.399 |
| 1905.... | 27.930 | 28.047 | 26.794 | 26.108 | 26.664 | 26.910 | 27.160 | 27.822 | 28.528 | 28.637 | 29.493 | 29.977 | 27.839 |
| 1906.... | 30.113 | 30.464 | 29.854 | 29.984 | 30.968 | 30.185 | 30.113 | 30.529 | 31.483 | 32.148 | 32.671 | 32.003 | 30.868 |
| 1907.... | 31.769 | 31.852 | 31.325 | 30.253 | 30.471 | 30.893 | 31.366 | 31.637 | 31.313 | 28.863 | 27.154 | 25.362 | 30.188 |
| 1908.... | 25.738 | 25.855 | 25.570 | 25.133 | 24.377 | 24.760 | 24.514 | 23.858 | 23.877 | 23.725 | 22.933 | 22.493 | 24.402 |
| 1909.... | 23.843 | 23.706 | 23.227 | 23.708 | 24.343 | 24.166 | 23.519 | 23.588 | 23.743 | 23.502 | 23.351 | 24.030 | 23.706 |
| 1910.... | 24.154 | 23.794 | 23.690 | 24.483 | 24.797 | 24.651 | 25.034 | 24.428 | 24.567 | 25.596 | 25.680 | 25.160 | 24.670 |
| 1911 ... | 24.865 | 24.081 | 24.324 | 24.595 | 24.583 | 24.486 | 24.286 | 24.082 | 24.209 | 25.594 | 25.649 | 25.349 | 24.592 |
| 1912.... | 25.887 | 27.190 | 26.875 | 27.284 | 28.038 | 28.215 | 27.919 | 28.375 | 29.088 | 29.299 | 29.012 | 29.320 | 28.842 |

AVERAGE PRICE OF SILVER IN NEW YORK.
(In cents per fine ounce.)

| Year. | Jan. | Feb. | Mar. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1904.... | 57.055 | 57.592 | 56.741 | 54.202 | 55.430 | 55.673 | 58.095 | 57.806 | 57.120 | 57.923 | 58.453 | 60.563 | 57.221 |
| 1905.... | 60.690 | 61.023 | 58.046 | 56.600 | 57.832 | 58.428 | 58.915 | 60.259 | 61.695 | 62.034 | 63.849 | 64.850 | 60.352 |
| 1906.... | 65.288 | 66.108 | 64.597 | 64.765 | 66.976 | 65.394 | 65.105 | 65.949 | 67.927 | 69.523 | 70.813 | 69.050 | 66.791 |
| 1907.... | 68.673 | 68.835 | 67.579 | 65.462 | 65.981 | 67.090 | 68.144 | 68.745 | 67.792 | 62.435 | 58.677 | 54.565 | 65.327 |
| 1908.... | 55.678 | 56.000 | 55.365 | 54.505 | 52.795 | 53.663 | 53.115 | 51.683 | 51.720 | 51.431 | 49.647 | 48.769 | 52.864 |
| 1909.... | 51.750 | 51.472 | 50.468 | 51.428 | 52.905 | 52.538 | 51.043 | 51.125 | 51.440 | 50.923 | 50.703 | 52.226 | 51.502 |
| 1910.... | 52.375 | 51.534 | 51.454 | 53.221 | 53.870 | 53.462 | 54.150 | 52.912 | 53.295 | 55.490 | 55.635 | 54.428 | 53.486 |
| 1911. .. | 53.795 | 52.222 | 52.745 | 53.325 | 53.308 | 53.043 | 52.630 | 52.171 | 52.440 | 53.340 | 55.719 | 54.905 | 53.304 |
| 1912.... | 56.260 | 59.043 | 58.375 | 59.207 | 60.880 | 61.290 | 60.654 | 61.606 | 63.078 | 63.471 | 62.792 | 63.365 | 60.835 |

The Indian government in the latter part of the year conducted an unusual operation by purchasing quietly and under cover a large quantity of silver for use in coinage. So adroitly was this done that the market did not suspect what was going on until the shipment was actually made.

Coined silver in the United States on Jan. 1, 1913, is estimated as fol-
s: Standard dollars, $565,481,020; subsidiary coins, $174,538,163;
al, $740,029,183.

## Commercial Movement of Gold

In 1912, as in 1911, the gold production of the year was largely absorbed in commercial channels. The great commercial and industrial activity in the United States, combined with its large crops and its heavy exports of grain, cotton, oil, copper and steel, enabled it not only to hold its own production but to import some $8,500,000 more than it exported, making an increase of about $100,000,000 in its gold stocks. Most of this appears in the Treasury Department's estimate of gold in the United States as of Jan. 1, 1913, which is as follows: Treasury current balance and redemption reserve, $170,983,732; held against gold certificates, $1,084,434,169; in banks and circulation, $623,159,221; total, $1,878,577,122. The total compares with $1,797,721,560 at the close of 1911, showing an increase of $80,855,562 during the year. This estimate seems to be a little excessive, as it hardly allows a sufficient amount of gold used in the arts. According to the report of the Director of the Mint, that branch of the Government in 1912 sold $38,000,000 worth of gold bars for consumption in the arts in the United States and Canada, as against $35,000,000 in 1911. The net consumption of new gold, including coin, for use in the arts in the United States and Canada in 1912 is estimated at $35,000,000, and in the world, excluding Asia, at between $100,000,000 and $115,000,000.

In Europe the industrial conditions were also very active, and in the last four months of the year there was also a strong demand from the banks, owing to the financial disturbances resulting from the Balkan war and the fear that the conflict might extend. To this must be added the fact that the cost and waste of war are great gold absorbers, and it will take some time to settle this disturbance and finally adjust the absolute losses, to say nothing of the heavy adjustments required on the bourses of almost all Europe. The international banking firms have estimated that since the outbreak of the war, fully $500,000,000 in gold has been taken out of circulation, throughout Europe. The aggregate gold holdings of the great European national banks at the close of 1912 were reported at $2,513,714,000, an increase over 1911 of $95,016,500 only.

There was a notable increase in the taking of gold by India, the total being approximately $71,000,000, an increase of 35 per cent. over 1911. This was evidence of the prevailing prosperity in India and of the tendency in that country to hoard gold instead of silver. Egypt was also a large taker of gold, having received about $38,000,000, or more than twice what it returned.

The visible increases in the United States and the European banks, with the absorptions of India and Egypt, thus account for about $285,000,000 of the production, to which must be added about $60,000,000 taken

by Argentina, Brazil and other South American countries, making a total of $345,000,000 and leaving $125,000,000 to be accounted for by use in the arts and by private hoarding. Apparently over 70 per cent. of the new gold in 1912 passed into the channels of commerce, though from this must be deducted a large part of the Indian takings, which must be considered additions to the world's reserve hoards rather than to its active currency.

## Gold and Silver Mining in the United States.

*Alabama.*—The production of gold in Alabama in 1912, as reported by the U. S. Geol. Surv., was 809 oz., valued at $16,724, against 915 oz., valued at $18,916, in 1911. The silver output (entirely from gold ores) was 168 oz. in 1912, against 171 oz. in 1911. No placer gold was reported from Alabama in either 1912 or 1911 and the precious metal output for the state was mainly that of the Hog Mountain or Hillabee mine, in Tallapoosa County, although the Tallapoosa mine, in the same county, and the Storey mine, in Talladega County, also produced some gold. The gold and silver output was all derived from siliceous ores, chiefly by cyanidation, 5693 short tons of these ores being treated in 1912, with an average recovery of $2.96 a ton, against 6360 tons in 1911, with a recovery of $2.99 and 9763 tons in 1910, with a recovery of $3.41.

PRODUCTION OF GOLD IN THE UNITED STATES. (a)

| States. | 1909. | | 1910. | | 1911. | | 1912. | |
|---|---|---|---|---|---|---|---|---|
| | Fine Ounces. | Value. (b) | Fine Ounces. | Value. (b) | Fine Ounces. | Value. (b) | Fine Ounces. | Value. (b) |
| Alabama | 1,413 | $29,200 | 1,593 | $32,900 | 890 | $18,400 | 855 | $17,674 |
| Alaska | 984,015 | 20,339,600 | 787,148 | 16,271,800 | 806,179 | 16,665,200 | 842,108 | 17,398,943 |
| Arizona | 127,083 | 2,626,800 | 165,113 | 3,413,200 | 170,348 | 3,521,400 | 159,890 | 3,303,504 |
| California | 1,001,625 | 20,703,600 | 988,854 | 20,441,400 | 964,041 | 19,928,500 | 967,443 | 19,988,486 |
| Colorado | 1,056,923 | 21,846,600 | 992,967 | 20,526,500 | 925,839 | 19,138,800 | 909,519 | 18,791,710 |
| Georgia | 2,100 | 43,400 | 1,161 | 24,000 | 1,548 | 32,000 | 478 | 9,881 |
| Idaho | 65,031 | 1,344,200 | 50,113 | 1,035,900 | 65,688 | 1,357,900 | 63,110 | 1,303,917 |
| Montana | 181,427 | 3,750,100 | 179,974 | 3,720,400 | 176,554 | 3,649,700 | 156,589 | 3,235,287 |
| Nevada | 792,753 | 16,386,200 | 913,015 | 18,873,700 | 875,438 | 18,096,900 | 645,253 | 13,331,680 |
| New Mexico | 12,230 | 252,800 | 23,084 | 477,200 | 36,847 | 761,700 | 29,280 | 604,961 |
| North Carolina | 1,519 | 31,400 | 3,122 | 64,500 | 3,478 | 71,900 | 6,910 | 142,760 |
| Oregon | 40,106 | 829,000 | 32,960 | 681,400 | 30,679 | 634,200 | 30,531 | 630,801 |
| South Carolina | 358 | 7,400 | 1,827 | 37,800 | 972 | 20,100 | 754 | 15,587 |
| South Dakota | 318,026 | 6,573,600 | 260,266 | 5,380,200 | 359,402 | 7,429,500 | 377,311 | 7,795,680 |
| Tennessee | 212 | 4,300 | 136 | 2,800 | 576 | 11,900 | 478 | 9,881 |
| Texas | 19 | 400 | 18 | 400 | 189 | 3,900 | 492 | 10,170 |
| Utah | 203,836 | 4,213,300 | 208,627 | 4,312,700 | 217,020 | 4,486,200 | 211,845 | 4,376,971 |
| Virginia | 193 | 4,000 | 44 | 900 | 150 | 3,100 | 424 | 8,755 |
| Washington | 20,755 | 711,359 | 38,992 | 806,000 | 40,635 | 840,000 | 13,796 | 285,044 |
| Wyoming | 189 | 3,900 | 199 | 4,100 | 1,030 | 21,300 | 1,108 | 22,884 |
| Other States | 309 | 6,400 | 283 | 5,900 | 5 | 100 | 15 | 310 |
| Total | 4,810,122 | $99,425,200 | 4,649,496 | $96,113,700 | 4,677,508 | $96,692,700 | 4,418,189 | $91,284,886 |
| Porto Rico | 29 | 600 | 50 | 1,000 | 97 | 2,000 | ..... | ..... |
| Philippine Islands | 11,978 | 274,600 | 7,471 | 154,400 | 9,448 | 195,300 | 19,372 | 400,248 |
| Total | 4,822,129 | $99,673,400 | 4,657,017 | $96,269,100 | 4,687,053 | $96,890,000 | 4,437,561 | $91,685,134 |

(a) The statistics in this table are reported by the Director of the Mint, those for 1912 being the preliminary figures (subject to revision). (b) At $20.67 per oz.

PRODUCTION OF SILVER IN THE UNITED STATES. (a)

| States. | 1909. | | 1910. | | 1911. | | 1912. | |
|---|---|---|---|---|---|---|---|---|
| | Fine Ounces. | Commercial Value. (d) | Fine Ounces. | Commercial Value. (d) | Fine Ounces. | Commercial Value. (d) | Fine Ounces. | Commercial Value. (d) |
| Alabama | 200 | $103 | 300 | $160 | 200 | $107 | 237 | $144 |
| Alaska | 198,600 | 102,283 | 153,900 | 82,336 | 468,300 | 249,604 | 516,224 | 313,864 |
| Arizona | 2,523,600 | 1,299,700 | 2,655,700 | 1,420,800 | 3,228,900 | 1,721,004 | 3,456,989 | 2,101,849 |
| California | 2,304,900 | 1,187,070 | 1,791,600 | 958,506 | 1,270,900 | 677,390 | 1,255,192 | 763,157 |
| Colorado | 8,846,300 | 4,556,020 | 8,523,000 | 4,559,805 | 7,331,200 | 3,907,530 | 8,350,316 | 5,076,992 |
| Georgia | 200 | 103 | 300 | 160 | 600 | 320 | 65 | 40 |
| Idaho | 6,755,900 | 3,479,422 | 7,027,000 | 3,759,445 | 8,184,900 | 4,362,552 | 7,703,721 | 4,683,862 |
| Illinois | 900 | 464 | 2,000 | 1,070 | 4,000 | 2,132 | 3,740 | 2,274 |
| Michigan | 217,600 | 112,068 | 262,200 | 140,277 | 507,700 | 270,604 | 543,360 | 330,363 |
| Missouri | 15,200 | 7,828 | 32,200 | 17,227 | 49,100 | 26,170 | 25,311 | 15,389 |
| Montana | 12,034,500 | 6,198,004 | 12,282,900 | 6,571,351 | 12,163,900 | 6,483,359 | 12,338,589 | 7,501,862 |
| Nevada | 10,119,200 | 5,211,606 | 12,366,000 | 6,615,810 | 13,185,900 | 7,028,085 | 13,042,118 | 7,929,608 |
| New Mexico | 324,200 | 166,969 | 779,000 | 416,765 | 1,341,400 | 714,966 | 1,251,412 | 760,858 |
| North Carolina | 400 | 206 | 8,300 | 4,440 | 1,000 | 353 | 3,783 | 2,300 |
| Oregon | 69,600 | 35,845 | 43,800 | 23,433 | 44,800 | 23,878 | 79,896 | 48,577 |
| South Dakota | 196,300 | 101,098 | 120,600 | 64,521 | 200,300 | 106,760 | 200,796 | 122,084 |
| Tennessee | 65,300 | 33,631 | 69,800 | 37,343 | 107,000 | 57,031 | 109,773 | 66,742 |
| Texas | 408,100 | 210,180 | 364,400 | 194,954 | 444,200 | 236,759 | 420,994 | 255,964 |
| Utah | 10,551,100 | 5,434,024 | 10,445,900 | 5,588,556 | 11,630,600 | 6,199,110 | 12,795,072 | 7,779,404 |
| Virginia | 6,400 | 3,296 | 200 | 107 | 200 | 107 | 7,974 | 4,848 |
| Washington | 75,200 | 38,730 | 204,900 | 109,621 | 230,300 | 122,750 | 258,152 | 156,956 |
| Wyoming | 1,800 | 927 | 1,300 | 695 | 700 | 373 | 298 | 181 |
| Other States | 3,000 | 1,545 | 800 | 428 | 100 | 53 | 241 | 146 |
| Total | 54,718,500 | $28,181,122 | 57,136,100 | $30,567,810 | 60,396,200 | $32,191,177 | 62,364,253 | $37,917,464 |
| Philippine Isla. | 3,000 | 1,545 | 1,800 | 963 | 3,200 | 1,706 | 5,650 | 3,435 |
| Total | 54,721,500 | $28,181,681 | 57,137,900 | $30,568,773 | 60,399,400 | $32,192,883 | 62,369,903 | $37,920,899 |

(a) The statistics in this table are reported by the Director of the Mint, those for 1912 being the preliminary figures (subject to revision). (c) Included in other States. (d) Based on the average value for the year at New York, as follows: 1909, 51.502 cents; 1910, 53.486 cents; 1911, 53.304 cents; 1912, 60.835 cents per oz.

*Alaska* (By Alfred H. Brooks).[1]—The value of the gold output in 1912 was $17,398,943 as compared with $16,665,200 in 1911. The silver production in 1912 had a value of $314,000 against $249,604 in 1912.

The gold-mining industry was marked by important advances in the development of lode deposits. Work was continued on a number of large lode enterprises in the Juneau district, and advances were made at Fairbanks and in other districts. In addition to this, promising discoveries of auriferous quartz were made at Port Wells and in the Innoko-Iditarod region, as well as in other parts of the territory.

The output from the placer mines was less than in 1911. On the other hand, discoveries of rich auriferous gravels were made on Hammond Creek and in the Koyukuk Valley, and workable placers were found in the Ruby district. Extensions of gold-bearing gravels were also found in several of the older districts. The installation of large plants has not yet gone ahead rapidly enough to insure the keeping up of gold-placer production. It is significant, however, that the output in Seward Peninsula was practically the same as that of 1911. The maintenance of this

[1] *Eng. and Min. Journ.*, Jan. 11, 1913.

output in Seward Peninsula is to be credited to the installation of dredges, which was continued in 1912 as in the previous year. In 1912 about 40 dredges were operated in Alaska, besides a number of others under construction. Of these, three are in the Fortymile district, one in the Fairbanks district, one in the Birch Creek district, one in the Iditarod district, one on the Kenai Peninsula, and the rest on Seward Peninsula. (For a description of five of these new dredges, see *Eng. and Min. Journ.*, Jan. 25, 1913.)

About 22 lode mines in Alaska produced gold in 1912, compared with 18 in 1911. In addition to this, development work was done on many lode prospects widely distributed over the territory. The value of the output from auriferous lodes in 1912 is believed to be about $4,600,000, an increase of about $400,000 over that of 1911. This increase must in large measure be credited to the Treadwell group of mines, but there was also a large production from various small properties in different districts.

The most noteworthy advances in 1912 were in the Juneau district. The Treadwell mine increased its gold output. Work was continued on the 6000-ft. tunnel of the Alaska-Juneau mine and was begun on an adit of the Alaska-Gastineau, which will be about two miles in length. This tunnel is to undercut the Perseverance mine, which, with adjacent properties on Sheep Creek, is now controlled by the Alaska Gold Mines Co. A mill having an initial capacity of 6000 tons per day is under construction, and will probably go into operation late in 1914. The ore is estimated to yield $1.50 per ton, at a cost of 75 cents, a figure thought to be possible by reason of the great size of the ore-bodies and their ease of mining. These enterprises, together with the continuation of work on the Kensington mine and the reopening of the Jualin mine, in the Berners Bay district, constitute an assurance that the production of gold in Alaska will not fall off, even aside from the promise of a larger output from other parts of the territory. It is reported that discoveries of rich gold-bearing quartz veins have been made on Funter Bay, Admiralty Island. Two mines were operated in the Sitka district, as in the previous year.

There was considerable advance of auriferous lode mining in the Ketchikan district in 1912. The Goldstream mine was again operated, supplying a five-stamp mill. A 10-stamp mill was installed at the Valparaiso mine.

The Cliff mine, of the Valdez district, continues to be the only gold-lode property in the Prince William Sound region which made any substantial output.

Work was continued on the auriferous lodes of Kenai Peninsula and the Willow Creek district. Three small mills, two on Falls Creek and one

on Porcupine Creek, were operated for a part of the year. Three mills were operated in the Willow Creek district, and development work was advanced. It is reported that two of these properties are to be consolidated and opened on a large scale.

Although the output from the Fairbanks placers decreased, there was greater activity in lode mining and prospecting than in 1911. Most of the operations were conducted on a small scale, and the total output of gold was not large, but a large amount of development work was accomplished in 1912. Six stamp mills were operated for a part of the year, and six other mills were being installed in the late summer. Statistics at hand indicate that the average recovery of free gold from these operations is about $50 per ton. In only two places are the concentrates being saved. Lode prospecting continued with increasing activity in 1912, and probably more than 200 men were engaged in this work. The notable features of the lodes are their great number, small size, and high tenor. Most of the veins from which free gold can be obtained by panning are composed almost entirely of quartz, with sulphides either absent or present only in subordinate amounts. Stibnite is the most common of the sulphides. Most of the veins have been discovered in two areas—one stretching east and west from Pedro Dome and the other in the vicinity of Ester Dome.

The influx of prospectors into the Innoko-Iditarod region during the last two years stimulated the search for lode deposits, but little was accomplished in actual development. In 1912 an auriferous-quartz deposit was opened on Gaines Creek, and a small mill was installed. This operation was successful.

The Apollo mine, on Unga Island, continued in 1912 to be the only productive lode mine in southwestern Alaska. Some work was continued on lode prospects in the Iliamna region, notably on the Duryea silver-lead deposit. There was but little advance in quartz mining in 1912 in Seward Peninsula. The New Era Mining Co. opened a quartz lead near Snow Gulch, where a four-stamp mill was installed. Considerable ore was also treated at the Nome custom mill.

*Placer Mining.*—The output from Alaska placer mines in 1912 was half a million dollars less than that of the previous year. The decrease occurred mainly in the Fairbanks and Innoko-Iditarod regions. On the other hand, a discovery of rich placer ground was made in the Koyukuk district, and promising finds were made in the Ruby district and the Innoko-Iditarod region. A little mining was done at Juneau and some larger operations were carried on in the Porcupine district. Beach mining continued to employ a score of men at Yakataga and probably as many more in southwestern Alaska, especially on Kodiak Island. The season in the Nizina district was successful except for the floods which occurred

in the latter part of the summer and caused much damage to the two large plants there installed. Hydraulic operations were continued on Kenai Peninsula and at Crow Creek, as in previous years. A dredge installed in 1911 was operated on Kenai River for part of the season in 1912.

New discoveries in the Fairbanks district were principally on creeks which have already yielded some gold. The most important was on Eva Creek. The work of the year has also increased the area known to be underlain by workable gravels in the Chatanika Flats, near the mouths of Dome and Cleary creeks. The Fairbanks Creek dredge was operated throughout much of the open season. The gold produced at Fairbanks came chiefly from Goldstream Creek, the lower parts of Dome and Cleary creeks, and Ester, Eva, and Fairbanks creeks. It is estimated that between 130 and 140 different plants were operated and that from 900 to 1500 men were employed.

In the Circle district the placer gold was taken chiefly from the mines of Mastodon, Deadwood, Eagle, Mammoth, Switch, and Independence creeks. It is estimated that about 27 mines were worked during the winter and 32 in the summer of 1912, employing from 60 to 100 men in the winter and from 145 to 175 in the summer. A dredge installed on Mastodon Creek was operated during the summer of 1912. Hydraulic plants were operated on Mammoth, Mastodon and Eagle creeks.

The Fortymile district had a successful season. Three dredges were operated there during the summer. It is estimated that about 25 mines were operated in the winter of 1912 and about 50 during the summer. The Koyukuk district had a successful season in 1912.

It seems certain that the Ruby Creek district will become a gold producer of some importance. In 1912 operations were practically confined to six creeks, all lying within a small area about 25 miles south of the town of Ruby, on the Yukon. About 150 men were employed in this district on 30 claims, and the value of the gold production was probably in excess of $150,000.

About 24 claims, on five creeks and employing 140 men, were worked in the Innoko district during 1912. No new discoveries were made. In the Iditarod district Otter and Flat creeks continue to be the most important producers of placer gold. A dredge was installed on the upper part of Flat Creek during the winter of 1912 and was operated for the latter part of the open season. It is estimated that 34 mines were operated in the Iditarod district in 1912. These were distributed on six creeks and employed about 650 men. Of these plants, one is a dredge, 18 are equipped with steam machinery, and the rest are operated by manual methods.

There was no abatement of dredge installation on Seward Peninsula

in 1912. In 1912, 39 dredges were completed or in process of erection. The dredge season began in May, but most of the machines were not operated until the first steamers brought in the dredge crews, about June 15. By August, about 30 dredges were in operation and a number of others were started before the close of the season. Dredging continued until about the middle of October. These dredges are widely distributed over the peninsula, some being operated or under construction in every district which has yielded placer gold.

*Arizona.*—The output of gold in 1912 increased over that of 1911 by about 3 per cent., and was worth $3,303,504. The most important producing mines, the Tom Reed and Gold Road, in Mohave County, made a record of nearly $2,000,000 for the year, of which $1,100,000 came from the Tom Reed, which is now paying a 7 per cent. monthly dividend, or about $65,000 per month. Developing mines are the Lexington-Arizona, Leland-Mitchell, Pioneer, Boundary Cone, Curry & Alexander, Iowa, Tom Reed Extension, Telluride, Sunnyside, Crown City, Ruth and numerous smaller properties. The Lexington-Arizona, about 1 mile south of the Tom Reed, has three shafts going down. The Leland-Mitchell recently equipped for deep work, is sinking to 600 ft. At the Tom Reed the development of the outlying properties is going forward steadily, the mine and mill giving employment to 80 men. The Tom Reed mill is crushing 80 to 100 tons daily from the mine, the rest of the material milled being tailings. One of the problems involved in handling the ores of the district is the excessive cost of electric power, which was until recently $14 per horse-power per month. It is understood that a new contract, at much lower figures, has been made by the Gold Road company.

Silver production increased about 2 per cent.; the total output was worth $2,108,763. Some of the increase was attributable to shipments of argentiferous lead ore from Mohave and Cochise Counties. Among the shippers of silver ore was the World's Fair property which, it is claimed, received higher returns per ton on its total shipments for the year than any other mine in continuous operation in the state. The total tonnage shipped was not large. It was reported at the close of the year that the Copper Queen's engineers had made an examination and that an offer had been made to the owners of the property.

*California* (By Lewis H. Eddy).—The value of the gold produced in California in 1912 was $19,988,486, a decrease from 1911 of $322,501. The production of silver in 1912 was 1,255,192 oz., a decrease of more than 50 per cent. from 1911.

In the case of both metals, the decrease was largely due to the continued suspension of the Balaklala smeltery, and to the fact that the Bully

Hill smeltery was still experimenting in zinc smelting and produced no commercial quantity of gold or silver. Other causes contributing to the 1912 results were a slight shortage of water and temporary closing of some of the large mines on account of accidents, which stopped ore extraction and closed down the mills temporarily. Another contributory cause was the special attention given to exploration and development. In some of the mines of the Mother Lode this was due to the necessity for finding new ore-bodies; in others, production was sacrificed to development. The decrease in silver was further due to experiments in progress at the Campo Seco smeltery.

A large amount of mine development, surface improvement, and new installation was in progress during the year. Some of this work was a continuation of that begun in 1911, but a large proportion of it was begun in 1912. Development included the exploring of new ore-bodies in the producing mines, the reopening of old mines, the deepening of shafts and the advancing of tunnels. Improvements included new stamp mills, cyanide plants, hoisting machinery, compressors, pumps, mineaphones, power drills and the substitution of electric for steam power. In the Mother Lode region, progress extended to all the counties, but was particularly active in Amador and Tuolumne.

In Amador County, the main vertical shaft at the Kennedy was deepened to 3700 ft., and will be continued to 4000 ft. New orebodies were encountered above the lowest working level. The Argonaut prepared for the deepening of its inclined shaft to 4000 ft. The Central Eureka encountered a new ore-body in the 2800-ft. level. The Oneida was purchased during the year by the South Eureka Mining Co. New ore was disclosed below the 1500-ft. level in the Zeila. The reopening of the Lincoln and Wildman-Mahoney by the Lincoln Consolidated advanced into Wildman ground, where a 9-ft. vein was encountered on the 1950-ft. level, 400 ft. below the old Wildman workings. The Pacific shaft of the Plymouth Consolidated was unwatered and pay ore was discovered in the lower levels. The Keystone shaft was unwatered, cleaned and repaired, and deepened to 2000 ft. The Hardenburg new vertical shaft was sunk to 1070 ft., and the ore-body cut by a 220-ft. drift. Improvements in Amador County during the year included a new 20-stamp mill at the East Eureka; new hoisting machinery and gallows frame and the beginning of a new 20-stamp mill at Hardenburg; new steel gallows frame at the Bunker Hill; new hoist at the South Jackson; new gallows frame, hoists and pumps at the Plymouth; new compressors and pumps at the Fremont and the South Amador.

In Tuolumne County the important new installations were: A 75-ton cyanide plant at the Black Oak; a new 20-stamp unit added to the 20-

stamp mill, and a new electric hoist at the Dutch Consolidated. New orebodies were disclosed in the Dutch, the Harvard, Eagle-Shawmut and the App. The App was closed and the mine sold under mortgage in December. The important mines reopened were the Clio, Mammoth, Tarantula, Jumper, Atlas, and some smaller mines at Tuttletown.

In Calaveras County, the Angels mine was the only large one operated steadily during the year. The Utica was closed temporarily on account of shortage of water; the Gold Cliff had two interruptions on account of accidents in the shaft; the Dolling discontinued extraction and milling for a part of the year, but continued development and opened a new large orebody and prepared for the installation of an underground electric hoist; 10 new stamps were added to the 30-stamp mill early in the year. The Melones installed a new electric hoist, after having encountered a new vein of high-grade ore.

In the last half of 1912, much development was done in the Forbestown district, in Butte County. The Gold Bank was reopened; a new shaft was sunk at the Burlington mines, and a number of new and old properties were put in working order. There was also a good deal of activity in the Magalia district.

New installations in Nevada County included a 100-ton cyanide plant at the Pennsylvania, a duplicate of the plant installed at the Empire in 1911; an electric hoist and pump at the Sultana; an electric hoist at the Golden Point; a complete electric plant at the Artic; about 1 mile of the 5-mile flume under construction by the Delhi mine was completed. Development at the Champion mine, operated by the North Star Mines Co., was successfully advanced; 20 stamps were placed in commission, and preparations were made for the installation of a cyanide plant. In some of the districts in Sierra County there was a scarcity of water, but in general the county was prosperous. Siskiyou County made some advance in quartz mining.

Gold mining, in Shasta County, was greatly retarded by the closing of Balaklala smeltery. The Midas mine, at Harrison Gulch, and the Gladstone, at French Gulch, showed substantial progress during the year, and preparations were made for the installation of a cyanide plant at the Midas.

Trinity County advanced in quartz mining and also in the opening of new dredge placers. The Alta Bert and the Trinity Dredging Co. had a successful season. The Craig Mining Co., at Dedrick, began the installation of a 40-stamp mill.

New gold discoveries were made in Willow Creek district, Humboldt County. The mines in the Hoag (Highgrade) district, Modoc County, produced some high-grade ore, but the scheduled boom failed to hold investors. Development gave promise of a few good mines.

Gold mining in the Randsburg district, in Kern County, progressed materially in 1912. The King Solomon, the Butte, the Consolidated Mines and the Yellow Aster were the important producers. At the close of the year there was a prospect of securing electric power. The Placer Gold Co. installed a new plant for extracting gold and tungsten from gravel.

*Colorado* (By George E. Collins).—The completion of the Roosevelt drainage adit led to the gradual unwatering of a large part of the Cripple Creek district at the rate of several inches daily. By the end of the year the El Paso, Portland and other important mines were drained to the bottom. An important discovery of sulphide ore in the 1600-ft. level of the Portland mine affords hope for an indefinite continuance of productiveness. The recognized success of the drainage adit has led to the discussion of various schemes for still deeper drainage, either by lower adits, or a central pumping station.

The hopes of improvement in Cripple Creek metallurgy, which were based on the Clancy process at the Ajax Mill, were not sustained by results, and the mill is being remodeled with a view to return to more nearly standard practice. At the Portland and Stratton's Independence mills good results are being realized in the treatment of low-grade and dump ores. The last year witnessed the closing down of the United States Reduction & Refining Co.'s Colorado City plant, and with it the final supremacy of cyanidation in competition with chlorination.

In Gilpin and Clear Creek Counties there were no new developments of importance; the output continues relatively small. With the exception of the Gunnell, none of the larger mines along the line of the Newhouse Tunnel is as yet unwatered by seepage through cracks in the country; the work of unwatering by laterals to strike the known watercourses, or by actual connection with the present deep workings, made little progress during the year.

In the San Juan district, Telluride is by far the most active center, thanks to the activity of its three great mines, the Liberty Bell, Tomboy and Smuggler-Union. The Camp Bird, by a lucky discovery in the nick of time, has prolonged its life for a year or more.

At Silverton the three largest mines, the Silver Lake, Gold King and Iowa-Tiger, are being worked only in a small way by lessees. The Sunnyside continues to handle a large tonnage, but is increasingly dependent on the base-metal content of its ores.

At Aspen the bold attempt to unwater through the Free Silver shaft and reopen the deep levels for further prospecting was retarded by labor troubles and other difficulties. At Creede the plans for exploring the great Amethyst vein in depth through a central shaft are slowly taking

concrete form, and a shaft below the adit level was commenced. Meantime valuable discoveries are being made in a parallel vein. Elsewhere in Colorado no important new developments were recorded.

Placer mining around Breckenridge is fairly active, but the rest of the state has no similar deposits in course of exploration. The Twin Lakes placer near Granite, in the central part of the state, definitely suspended operation, as a result of legal proceedings brought on behalf of the towns further down the Arkansas River.

*Idaho* (By Robert N. Bell).—The increase of $135,000 in the gold output of Idaho during 1912 was due principally to a good water season throughout the state for hydraulicking, and to the steady operation of the dredging plants of the Boston-Idaho company at Idaho City, with a daily capacity of 12,000 cu. yd. of gravel, and of the new Kirtly Creek dredge near Salmon City, with a capacity of 6000 cu. yd. per day. The success of these plants has stimulated interest in other Idaho dredge ground and additional plants are in process of construction.

Several discoveries of gold ore were reported in the central part of the state, the most promising one being the Big Creek district in Idaho County. A transaction involving the advance payment of $5000 on the Moscow mine is reported. The deposit is a shear zone of pyritic quartz in porphyry and granite, careful sampling of which across its entire width of 150 ft. yields $3 per ton, at a maximum depth of 150 ft. This zone exhibits a length of several thousand feet. The gold yields readily to amalgamation and cyanide treatment. With its favorable natural facilities, the deposit should prove profitable if worked upon a sufficiently large scale and several other deposits of similar magnitude in the same district display evidence of large resources of pay ore.

The principal source of silver in Idaho is its lead ores, which carry a proportion of silver ranging from 1/8 to 1.5 oz. per unit of lead. The treatment of copper ores in Shoshone and Custer Counties, and the milling of siliceous gold-silver ores in Owyhee County also yield a good output of silver. The Delamar mine, in Owyhee County, maintained its normal output of over 200,000 oz. per year, together with about $250,000 worth of gold bullion. The exhaustion of this property has been predicted annually for years, but it has been kept alive by judicious management, increased tonnage, and ingenious adaptation of treatment to gradually receding values.

The Elias Myers Mines, in the same township as the Delamar, is a new silver venture recently acquired by a wealthy English investor of that name. It is now being developed under the direction of the engineering firm of Bambridge-Seymour Co., of London, England. A 16-drill compressor has been installed on the property, to be electrically

driven by current from the Trade Dollar lines of the Oregon-Idaho Power Co., and a 40-stamp mill is in prospect during 1913. The company's claims cover a series of vertical fissures 2 miles in length; these veins vary from a few inches to 10 ft. in thickness. They contain gray copper and antimonial silver ore; present development at a depth of 500 ft. indicates from 10 to 50 oz. silver per ton and $1.50 in gold.

*Nevada.*—Gold production in 1912 was less than in 1911, and with the exhaustion of the rich ore-bodies of the Goldfield Consolidated, the gold output of the state will probably lose its premier position unless some new rich discoveries are made. More gold ore was milled in 1912 than in 1911, but the grade of the ore treated at Goldfield, and in the National and Seven Troughs districts was lower. At the National mine the mill was burned in September and in July a cloudburst at Seven Troughs interfered with mining work. In Manhattan, Round Mountain and Fairview the production of the gold mines increased. The grade of Goldfield Consolidated ore fell from $25 per ton in January to $13 per ton in September; the company passed a dividend in December. The gold production of the state was about $13,300,000. The Aurora, Rexall and Rochester districts are about to become producers of gold.

The production of silver increased nearly 23 per cent., due to the increased production of silver at Tonopah and shipments of lead ore from Pioche, in Lincoln County.

The Comstock Lode (By Whitman Symmes).—Mining on the Comstock Lode did not prosper in 1912. The reason for this lay largely in the fact that there are in all 29 different companies, which are not all in agreement on a policy of unwatering and exploring the lode. In 1912 there was at one time considerable dispute between the Mexican and the Union as to ventilation. At the north end the water level remained a few feet below the 2500-ft. level, just where it was in January, 1911, when the Mexican first encountered the ore which it has since been stoping. Some new centrifugal pumps were installed at the C. & C. shaft and successfully handled the water formerly lifted from the 2500 sump by the Evans hydraulic elevators. Other pumps for unwatering the north-end mines to the 2700 level, through the old joint Ophir and Mexican winze, have been on hand for some time, but the work of installation was held up owing to inability of many of the companies to contribute to the Comstock Pumping Association, and differences as to the proportion that each should pay.

In 1912 the Mexican produced 20,000 tons of ore, averaging about $23 per ton. On account of the slowness of lowering the water and the consequent lack of new ground to explore in the Comstock Lode, Mexican has taken an option on the Keyes property, 1 mile east from its mill.

The Keyes was unwatered and is now being sampled. The Mexican also took control of a lease on the Monte Cristo, adjoining the Keyes, and is building an aërial tramway to it. The Monte Cristo has some $10 ore in sight. Ophir ran out of ore and for the first time in 5 years had to levy an assessment. The Crown Point and Belcher mines, in Gold Hill, milled large quantities of $5 to $10 ore, but as there was no cyanide plant in connection with the concentrating mill, the extraction was poor. Mexican completed construction of its mill and cyanide plant, and began milling early in the year, and Ophir completed a 100-ton cyanide plant in October to treat an accumulation of tailings stated to consist of 22,000 tons sampling better than $5. These tailings have lately been saved from the ore worked at the Kinkead custom mill.

Goldfield.—The report of the Goldfield Consolidated Mines Co. contains figures covering a period of 14 months ended on Dec. 31, 1912. During that period the property produced 415,786 tons of ore of an average value of $19.77, or a total of $8,220,238. The metallurgical losses and the cost of a small amount of ore purchased from a neighboring property leave the amount realized from the production in that period $7,652,045, or $18.40 per ton. The gross expenses, which include mining, milling, transportation, construction, taxation and general expense, were $2,765,-646, leaving net realization from operation $4,886,399.

The costs per ton during the 14 months' period were less by $1.36 than during the previous fiscal year. The noteworthy items in making up this figure are reduced costs of 28 cents per ton in milling, 61 cents per ton in marketing concentrates and 8 cents per ton in marketing bullion and 10 cents per ton in general expense. Additional milling facilities costing approximately $79,000 were put into operation in February, 1912. These facilities refer to the concentrate treatment plant, by means of which 50 cents per ton of ore milled has been saved through the elimination of the marketing of concentrate. Development work has been performed within the period to the extent of 48,146 ft. Mining costs $3.39 per ton; transportation, $0.09; milling, $1.66; concentrate treatment, $0.39, This makes a total of $5.53 on all operations. The dividend disbursements of the company to the end of 1912 have amounted to $23,839,067, the first dividend having been paid on Oct. 25, 1907.

Tonopah.—A vigorous growth of the mining industry is indicated by an increase from about 400,000 tons of ore of a gross value of $8,000,000 in 1911 to 474,521 tons of a gross value of $9,110,955 in 1912. The list of regular producers was augmented by one new mine and by the rejuvenation of one old mine. Many new or rejuvenated companies have started intelligent exploration work with excellent prospects of satis-

factory results. Dividends paid in 1912 amounted to $3,331,550, as against $3,060,624 in 1911.

The metal output for 1912 was 112,642 oz. gold and 11,027,736 oz. silver. The output was contributed by the leading mines in the proportions shown in the following table:

OUTPUT OF THE LEADING TONOPAH MINES IN 1912

| Mine. | Tons of Ore. | Gold Contents | Silver Contents. | Gross Value. | Mining Profit. |
|---|---|---|---|---|---|
| | | Ounces. | Ounces. | | |
| Tonopah-Mining Co. | 174,000 | 40,682 | 4,012,950 | $3,261,035 | $1,672,724 |
| Tonopah-Belmont Devel. Co. | 125,470 | 39,826 | 3,928,489 | 3,182,622 | 1,823,539 |
| Tonopah-Extension Mining Co | 53,195 | 8,886 | 857,398 | 766,669 | 233,945 |
| Montana-Tonopah Mining Co | 53,910 | ..... | ..... | 808,650 | ..... |
| West End Cons. Mining Co. | 40,588 | 9,137 | 900,309 | 742,274 | 250,000 |
| MacNamara Mining Co. | 19,203 | 2,534 | 236,959 | 222,562 | ..... |
| Jim Butler-Tonopah Mining Co. | 6,067 | 1,079 | 99,639 | 83,712 | ..... |
| Tonopah-Merger Mining Co. | 1,650 | ..... | ..... | 27,003 | ..... |
| Tonopah-North Star Mining Co. | 438 | 546 | 11,619 | 16,435 | ..... |

The Tonopah Mining Co. paid its normal dividends of $1,600,000 in 1912. The Tonopah-Belmont Development Co., despite a four months' period of greatly reduced production enforced by complete retimbering of its main shaft, yielded an increased tonnage and value. This property in 1912 opened many new veins and paid dividends of $1,500,000. The Montana-Tonopah Mining Co. increased its ore reserve greatly, having found a large body of rich ore in the "Shaft" vein, beside other new orebodies in "Triangle" and "Martha" veins. This company paid dividends amounting to $200,000 in 1912. The company acquired control of the Commonwealth mine in Arizona, where a new 350-ton mill and cyanide plant are under construction. The Tonopah Extension greatly increased its ore reserve over that of 1911; a new three-compartment shaft, to become the main operating shaft, is being sunk. In 1912, this company paid dividends of $75,000. The West End Company developed a large tonnage of ore above the 500-ft. level and is sinking its main shaft to the 1000-ft. level and crosscutting for the vein on the 600. This company owns control of the Halifax Mining Co. The Jim Butler-Tonopah Mining Co., after several years of unremunerative prospecting and development work, found ore on the 300-, 500- and 600-ft. levels from its Wandering Boy shaft, and from development work alone is making daily shipments of 50 tons. The Tonopah Merger, the new company that took over the holdings of the old Golden Anchor and Midway Extension companies became a producer in 1912. The company resumed the sinking of the old Golden Anchor shaft and at 980 ft. encountered ore.

About fourteen companies, other than those mentioned, are

vigorously pushing prospecting work; nearly this number of new shafts are being sunk at present. Of these, the Halifax, east of the Belmont, reached the greatest depth, 1400 ft. This prospecting work is being performed both to the east and to the west of the developed ore zone.

The mills of the district were augmented by the West End Company's 20-stamp mill, which was started in November, 1911; the MacNamara Company's 10-stamp mill, started in February, 1912, and the new 60-stamp mill of the Tonopah-Belmont Development Co., at Tonopah, started in July. All the new mills were equipped with tube-mills for regrinding, and at present all the mills in the district, with one exception, slime the total product; the capacity of the mills per stamp is much greater than in 1911.

The report of the Tonopah-Belmont Development Co. for the year ended Feb. 28, 1913, shows the net earning of the mine and both mills during the fiscal year to be $1,773,227 as compared with $1,802,081 for the previous year. The operating expenses of the mine for the fiscal year, compared with previous three years, are as follows: For the year ended in 1910, 36,930 tons of ore milled at a cost of $287,486; for 1911, 81,066 tons of ore milled at a cost of $498,164; 1912, 115,563 tons of ore milled at a cost of $560,446; 1913, 129,537 tons of ore milled at a cost of $564,722. The cost per ton varies from $7.78 in 1910 to $4.35 in 1913. At the Tonopah mill 84,886 tons of ore were milled at a total cost including direct and indirect expenses, $3.44 per ton. At the Millers plant 60,359 tons of ore were treated at a total indirect and direct cost of $4.16 per ton.

The Tonopah Mining Co., during the fiscal year ended Feb. 28, 1913, milled 173,336 dry tons of ore at a cost of $9.04 per ton, made up as follows: Mining, $3.27; milling, $2.67; freight on ore to mill, 74 cents; marketing mill product, 51 cents; and metal losses in milling and refining, $1.85 per ton. The average gross value of the ore milled was $18.16 per ton and profits $9.12 per ton, or practically 50 per cent. of the gross value of the ore. The mining cost of wet ore and waste hoisted was $2.73 per ton.

*New Mexico* (By W. Weston).—That an important mining camp exists in the Mogollon district in New Mexico, at the south end of the Mogollon Range, is apparently not generally known, although rich ore was discovered there in 1895. Up to 1905, the production was about $5,000,000 in gold, silver and copper, mainly from four mines, the Little Fanny mine, now owned and operated by the Socorro Mines Co., the Helen Mining Co., now the Treasure Mining & Reduction Co., owning the Confidence and other claims, the Ernestine Mining Co., owning the Last Chance claim, and the Mogollon Gold & Copper Co., owning the

Cooney mine. In 1905, all the mines except the Ernestine were closed, owing chiefly to lack of transportation and the low price of metals, but in 1909 the great success achieved by Ernest Craig, chief owner and manager of the Last Chance mine of the Ernestine company, who introduced up-to-date methods, machinery, cyanidation and concentration, instead of pan amalgamation, revived the whole district, and now all the mines are producing again.

The mines are 85 miles from the Santa Fé R.R. at Silver City, N. M., and as the general average of the ore is low, only a comparatively small tonnage was rich enough to bear the costly transportation to the smelters. The general average of the ores is about $20, and at present $7 ore is about the lowest that can be treated at a profit, and that only with the strictest economy and up-to-date appliances.

The Treasure Mining Co. has the advantage of the others in owning water power. The other companies use fuel oil for power purposes, which costs 16 cents per gallon, f.o.b. mine. Lumber is $45 per thousand, and miners' wages $3, $3.50 or $4 for machine men, and wagon freight on supplies from Silver City to Mogollon is $1 per 100 lb. The fare on the automobile line is $16.

*South Dakota* (By Jesse Simmons).—The year 1912 was the most prosperous in the history of mining in South Dakota. For 1911 the gross production of gold and silver is given at $7,537,700 by the Director of the Mint, and 1912 exceeded it by $379,500. The silver production is valued at about 1 1/2 per cent. of the gross for the two metals.

Early in 1912 many of the mines were working at a decided disadvantage, extremely severe winter weather interfering at nearly all of the properties, and causing a complete suspension of operations at the Wasp No. 2, for 40 days. Had the winter been less severe the production figures would probably have been 5 per cent. greater. Another item adversely affecting the production was the burning of the Mogul mill in March. After that date this company shipped a small daily tonnage to the Lundberg, Dorr & Wilson plant, at Terry, and for the year the company's production was fully $250,000 below the normal. The Homestake shows a gain in production of $560,953 for the year, and other producers show about normal figures.

The Homestake enjoyed the most prosperous year in its existence, handling largest tonnage, and the average value of the ore being higher than for many years past. The figures for 1912 were: 1,528,923 tons milled; $6,600,953 bullion produced, or an average of $4.317 per ton. The company announced in the latter part of the year that it would pay to its employees a sum equal to 7 per cent. of their earnings for the year 1912, this to be paid to each man on the payroll in December. In February,

1913, the stockholders voted to increase the capitalization of the company by the issue of 32,760 new shares of $10, to be distributed among all the stockholders as a 15 per cent. stock dividend. Also beginning in 1913, the monthly dividend rate was raised to 65 cents per share. Within the year the company completed and placed in operation the Spearfish hydro-electric plant, and this, with the Englewood plant, gives a total of 5450 h.p. for operating the mills and surface works around Lead. On Oct. 31 there was 2850 h.p. of this total being used, the principal applications so far being for the operation of the stamps and rock crushers. The electrification of other machinery is being undertaken, and before the close of 1913 practically all of the developed power will be in use.

Wasp No. 2, although operations were entirely suspended for 40 days in January and February on account of severe weather, had a prosperous year, disbursing $85,000 in dividends, or 17 per cent. on the capitalization. Everything about the property operated smoothly, and a few minor improvements were made. The mill capacity was maintained at 15,000 tons per month, bullion recovery amounting to $1.94 per ton on 158,840 tons mined.

Golden Reward made a good production, and erected a roaster at the Astoria mine. A Wedge furnace was installed, with a capacity of 75 tons per day, it being proposed to give the ore a preliminary roast before sending it to Deadwood for treatment in the company's cyanide plant. The plant is built so that with but little trouble the capacity can be doubled by installing duplicates of the present equipment. This company has an immense quantity of milling-grade ore which cannot be handled in its present mill, and if tests on roasting as a preliminary to cyanidation prove successful, the problem of the so-called "blue ore" has been solved. By the ordinary methods of cyanidation only 25 per cent. to 35 per cent. of the gold in such ore is recovered. Tracks have been laid so that ores can be brought from various other properties for roasting. Early in 1912 the company let leases in a number of the older mines, with the idea of getting the rims, backs and bottoms cleaned up.

The Trojan Company operated steadily throughout 1912, handling 60,475 tons, nearly all of which went to the cyanide mill. This ore yielded $291,723. Extensive improvements were completed. The mill supply comes from three mines, the Decorah, Empire and Portland, the first named being 4000 ft. from the mill. Early in 1913 the mill capacity will be doubled by the addition of leaching tanks and enlargement of the slime department.

The operations of Lundberg, Dorr & Wilson were confined principally to cyaniding custom ore, the majority of which came from the Mogul. The mill capacity is 115 tons per day. A comparatively small amount of

ore was taken from the company's properties, the Buxton and Big Bonanza. During the summer of 1912, the New Reliance mill was remodeled. The mill as now equipped handles the slime by a treatment consisting of continuous decantation in four Dorr thickeners and Portland filter. The mill contains 30 stamps, and is now in steady operation.

Other producers include the Victoria, where the mill was started in the fall of 1912, and the Deadwood Standard, which operated 60 days in the summer, suspending until the summer of 1913.

The Richmond Operating Co., at Galena, shipped a considerable quantity of lead-silver ore to the Omaha smelter. The Monarch mine, under lease to Nickoli brothers, produced a considerable amount of high-grade gold ore, which was shipped to smelters.

Among the new properties which have been exploited are the Bismarck, where a 300-ton cyanide plant has just been completed, and is practically ready for operation. This adjoins the Wasp No. 2. The Forest City property, near Hill City, was equipped with a model 5-stamp mill, and has been in steady operation for several months. The Otho company, at Spokane, is erecting a plant, a portion of the machinery being secured from an old mill at Mystic. The Black Hills Smelting Co. completed a small smeltery at Galena, and will shortly commence operations. The plant is designed to operate on the pyritic process. The sulphides will be secured from the Gilt Edge and other Galena properties, and dry ores from the Richmond, at Galena, and a number of the Bald Mountain properties.

*Utah.*—The Consolidated Mercur Gold Mines Co. has been staving off the inevitable for some years. In the fiscal year ended June 30, 1912, its operating profits were only $10,797, out of which $8239 had to be charged to depreciation on stores and on stock held in the Manning Lease Co. A dividend of $30,000 was paid in that year, partly from accumulated surplus. During the year, 67,816 tons of base ore, 119,776 tons of oxidized ore and 14,060 tons of old tailings were treated, with an average recovery of $2.45 per ton. The loss in tailings was $0.82 per ton, giving a total average value of all material treated during the year of $3.27. Mining cost $1.41 per ton of ore mined; treatment of tailings dump, $0.17 per ton of tailing; milling, $1.10 per ton of ore milled or a total of $2.42 per ton of ore treated. The final shut-down came in the first week of April, 1913, after an uninterrupted operation of 25 years, during which the mines now owned by the company afforded dividends of $3,415,000.

The gold recovered from the low-grade copper ores of Bingham showed an increase, but not enough to offset the loss of output at Mercur.

The Silver King Coalition, Daly West, and Daly-Judge, at Park City,

were the principal producers of silver-lead ore in 1912. The Centennial Eureka, at Tintic, contributed a silver output in its silver-copper ores, and to a less extent in its lead ores. The total increase in silver output was 115,000 oz.

*Washington.*—The gold production was valued at $680,964, according to the U. S. Geol. Survey, or $166,713 less than the output of 1911. The decrease was due to the fact that less ore was shipped from Republic, where material was stored awaiting the completion of two new cyanide mills.

The silver output increased from 243,781 oz. in 1911 to 413,538 oz. in 1912, an increase of over 69 per cent., largely from the Chewelah district, in Stevens County.

## Gold and Silver Mining in Foreign Countries

*Australasia.*—A steady decline continues in the gold yield. The output for 1912 was 2,636,391 oz. fine, compared with 2,877,295 oz. in 1911. The yield furnished by Western Australia is substantial evidence of the magnitude of operations in that state. However, the steady drop in the average value of the ore won, and the fact that no new mines of importance are being opened are matters of moment, considering the future of the industry.

In the eastern states, no results of any consequence were obtained, while the activity manifested in the other branches of the industry was the means of attracting the gold miners, and, consequently, prospecting was comparatively neglected.

In Victoria, which ranks next in importance to Western Australia as a gold producer, the yields from the established fields, such as Bendigo and Ballarat, fell considerably below the average of previous years. The decrease is not so pronounced in the case of Queensland, and the augmented production of the industrial metals makes up for the deficiency. The lessened yields from the Charters Towers and Gympie fields are mainly responsible for the shortage, and it would appear hopeless to expect any improvement under present conditions.

In New South Wales the gold yield is gradually diminishing, due in no small measure to the disappointing returns from the dredges. In the Cobar district, the principal center of gold mining in the state, the mines controlled by Great Cobar, Ltd., were vigorously worked, and the production for 1912 showed a considerable advance on that of the previous year. The output from the other fields was on a lessened scale.

The Dominion of New Zealand also records a lessened production, due to a cessation of operations at the Waihi mine through labor troubles,

which have existed for the last 6 months or more. However, it is expected that matters will be righted shortly, when this famous mine will once more take its place among the active producers.

PRODUCTION OF GOLD IN AUSTRALIA (a.)
(In fine ounces.)

| State. | 1905. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|---|
| New South Wales | 274,267 | 253,987 | 247,363 | 224,792 | 204,709 | 188,857 | 181,121 | 165,295 |
| Northern Territory | 7,287 | 12,759 | 5,160 | 5,633 | 5,682 | 5,109 | (e) 5,000 | (e) 5,000 |
| Queensland | 592,630 | 544,636 | 466,476 | 465,085 | 455,577 | 441,400 | 386,164 | 347,946 |
| South Australia | 10,983 | 8,037 | 4,834 | 2,898 | 7,111 | 6,603 | 3,537 | 6,592 |
| Tasmania | 73,541 | 60,023 | 65,355 | 57,085 | 44,777 | 37,048 | 31,101 | 27,973 |
| Victoria | 747,166 | 772,290 | 695,576 | 671,208 | 654,222 | 570,383 | 504,000 | 480,121 |
| West Australia (b) | 1,840,656 | 1,736,295 | 1,671,993 | 1,596,091 | 1,576,406 | 1,422,231 | 1,338,987 | 1,282,688 |
| Commonwealth | 3,546,520 | 3,388,027 | 3,156,757 | 3,022,792 | 2,948,484 | 2,661,631 | 2,449,910 | 2,325,595 |
| New Zealand (c) | 492,954 | 534,616 | 477,312 | 471,967 | 472,465 | 446,434 | 427,385 | 310,796 |
| Total Australia | 4,039,474 | 3,922,643 | 3,634,069 | 3,494,759 | 3,420,949 | 3,108,065 | 2,877,295 | 2,636,391 |

(a) From official publications. (b) Production reported by the Mines Department; in previous volumes the statistics have represented exports. (c) Exports. (e) Estimated.

PRODUCTION OF SILVER IN AUSTRALASIA.

| State. | 1910. | | 1911. | | 1912. | |
|---|---|---|---|---|---|---|
| | Ounces. | Commercial Value. | Ounces. | Commercial Value. | Ounces. | Commercial Value. |
| New South Wales (a) | 12,804,659 | $6,826,050 | 14,529,145 | $7,745,810 | 13,514,249 | $8,157,131 |
| Queensland | 861,202 | 460,743 | 549,015 | 273,642 | 569,181 | 322,336 |
| South Australia | 6,250 | 3,344 | 1,400 | 680 | 2,700 | 1,584 |
| Tasmania | 656,793 | 351,380 | (e)700,000 | 373,100 | (e)1,025,000 | 623,200 |
| Victoria | 18,800 | 10,157 | 19,147 | 10,397 | 17,424 | 10,714 |
| Commonwealth | 14,347,704 | $7,651,674 | 15,798,707 | $8,403,629 | 15,128,554 | $9,114,965 |
| New Zealand | 1,677,484 | 897,454 | 1,310,943 | 698,733 | (e)983,500 | 597,970 |
| Total | 16,025,188 | $8,549,128 | 17,109,650 | $9,102,362 | 16,112,054 | $9,712,935 |

(a) Metal produced in Australia, plus silver contents of concentrates exported. (e) Estimated.

New South Wales.—The total gold yield for 1912 was 165,295 oz. fine (£702,129), as compared with 181,121 oz. fine (£769,353) in 1911, a decrease of 15,826 oz., or nearly 9 per cent. The mines of the Cobar district were the chief producers, furnishing 66,801 oz. in 1912; the Mt. Boppy mine, while it retained its position as leading gold producer of the state, with an output of 17,305 oz. from 53,990 tons of ore, fell below its previous year's record by 8,889 oz., due to water shortage. The Gundagai division recorded an increase of £2,534 over 1911, due to enlarged output of the Long Tunnel mine. A slight increase was also made in the Wellington division, but elsewhere in the state decreased outputs prevailed. The yield from dredges in 1912 was 18,899 oz. fine (£80,276), a decrease of £18,969 from 1911. The Araluen division is the leading

dredging center, while other dredges operate in the Stuart Town and Gundagai divisions.

The bulk of the silver originating in New South Wales is obtained in the lead-zinc ores of Broken Hill, where operations were abnormally active during 1912, notwithstanding a shortage of labor. Rich silver-lead ores are also secured from the Yerranderie field, in spite of its remoteness and inaccessibility. Practically the whole output of argentiferous ores and concentrates is shipped outside of the state, more than half of them going to Europe, and the remainder being smelted in plants situated elsewhere in Australia. The total output of 13,514,249 oz. fine in 1912 was thus made up of 5,220,538 oz. smelted in Australia, and 8,293,711 oz. contained in 537,733 tons of ores and concentrates shipped outside of Australia.

Queensland—In 1912 the gold output was 347,946 oz. worth £1,477,979. For the first time the value of the annual copper output in Queensland exceeded that of the gold. In 1900, when the gold output reached its highest mark, that part of the production derived from base metals was only £5,200, whereas in 1912 the gold from this source was valued at £556,159.

The following table shows the relative proportions of gold obtained from different sources for the years 1911 and 1912:

DERIVATION OF GOLD IN QUEENSLAND.
(In fine ounces.)

| | 1911. | 1912. |
|---|---|---|
| Tons of ore treated | 464,552 | 347,466 |
| Tons of old tailings treated | 33,511 | 46,113 |
| Product from the above tonnage: | | |
| Mill gold | 199,820 | 147,972 |
| Cyanide gold | 30,147 | 24,536 |
| Gold from concentrates | 42,047 | 35,431 |
| Gold from old tailings | 4,393 | 5,246 |
| Gold from copper and other ores | 103,093 | 130,931 |
| Alluvial gold | 6,664 | 3,830 |
| Total fine gold from all sources | 386,164 | 347,946 |

At Mount Morgan, after attempting to adapt an existing plant to pyritic smelting, it has been decided to erect new furnaces and plant at a cost of £150,000 for the treatment of the auriferous copper ore combined with the pyritic ore from Many Peaks. The report of the company states that a large proportion of the ore treated during the last half year was won from areas not included in the published ore reserves, which remain at 1,433,000 tons of high-grade, and 1,997,000 tons of medium ore. To cheapen coal the management has examined coal areas near Blackwater Station on the Central Railway line. Mount Morgan pro-

duced 236,903 tons of ore in 1912, which with 100,480 tons from the Many Peaks, yielded 137,411 oz. of gold and 8793 tons of copper.

The completion of the smelting works at Forsayth, and the hesitating attitude of the Chillagoe Company as to development, have not been followed by great activity. Lack of transportation in this isolated region prevents shipments, and it is intended to erect concentrating machinery at the mine.

South Australia.—Of the total gold recovery amounting to 6592 fine ounces in 1912, rather less than one-half, or 2890 fine ounces, was derived from 6608 tons of quartz ores by amalgamation and cyaniding, the remainder being recovered in the refining of 6295 tons of copper. The largest productions from quartz ores were made by the Tarcoola government mill, and by the private mills at Kitticoola and Mt. Grainger. A discovery of rich silver ore was recorded near the Miltalie copper mine, 18 miles from Cowell.

Tasmania.—The total output of 37,973 oz. fine in 1912 was derived as follows: By amalgamation of quartz ores, 11,246 oz.; by cyanidation or chlorination, 10,175 oz.; alluvial workings, 562 oz.; in blister copper produced by the Mt. Lyell Mining & Ry. Co., 7351 oz.; in silver-lead bullion made by the Tasmania Smelting Co., at Zeehan, 8639 oz. (estimated).

Western Australia—Operations at the mines of the Ivanhoe Gold Corporation, at Kalgoorlie, in 1912 were as follows: Ore treated, 237,266 tons, containing 110,439 oz. of gold, and 23,263 oz. of silver; ore reserves to 2420 ft. depth, 1,080,850 tons. (East lode, 809,174 tons.) The main shaft is 2754 ft. depth, and is to be sunk deeper. Of the four lodes, the principal reserves are in the East and Middle lode, but development work in the former has not been satisfactory as to the grade of ore.

The costs at the new mill of the Yuanmi gold mines, West Australia, are reported as follows: Rock breaking, 5.30d.; ore transport, 2.45d.; milling, 2s. 3.19d.; vacuum filtration, 2s. 3.26d.; fine grinding, 4.34d.; precipitation and smelting, 4.45d.; disposal of residues, 2.23d.; total, 6s. 1.22d. per ton of ore treated. These figures are based on the milling of 5050 tons per month. The monthly tonnage has recently been increased to 5500 tons. The average extraction of gold amounts to 90 per cent. Owing to the presence of insoluble oxidized antimonial compounds, and of a little stibnite in the ore from the oxidized zone, it is impossible to obtain an extremely low tailing.

New Zealand.—The gold production of 1912 is reported at 336,840 oz. valued at £1,320,884; exports amounted to 310,796 oz., a decrease of 116,589 oz. from 1912. As the bulk of the silver produced in New Zealand is contained in gold bullion, its output in 1912 is estimated at 25

per cent. less than that of 1911, or at 983,500 oz. Exports of silver in 1912 were 779,261 oz., worth £82,471.

*Austria.*—In Bohemia, during 1911, only one of five gold mines was operated. At this mine, near Borkowitz, 323 persons were employed and 29,740 tons of ore were produced. In 1910 the output was 31,744 tons. The 513 tons of pyrite concentrates were treated at Freiberg, in Saxony, and yielded 55.5 kg. of fine gold; in addition, the above ore yielded 627.4 kg. of amalgam, containing 191.33 kg. of fine gold, and also yielded by cyanidation 9 kg. of fine gold; this is a total of 255.59 kg., valued at 789,291 K. ($158,000). By-product gold from silver and lead smelting, at Pribram, amounted to 4.97 kg.

The silver production of Bohemia in 1911 increased over that of 1910. The ore produced was 24,143 tons, valued at 4,097,745 K. ($818,000). The number of men employed at three mines was 2,300. The silver ores treated at Pribram amounted to 24,634 tons, from which, at the government works, 47,700 kg. of silver resulted. As a by-product, obtained at Vienna and Frankfort a/m., from amalgams and slimes produced in gold milling at the above mine, 97.3 kg. of silver were added, making a total silver production for Bohemia of 47,797 kg. The lead smelter in Littai, Krain, produced 2,111 kg. of silver, while 336 kg. were a smelter by-product at Brixlegg, in the Tirol, making a total silver production for Austria of 50,244.4 kg. in 1911.

*Brazil.*—The production of the Ouro Preto Gold Mines, Ltd., an English company, was slightly curtailed during 1912 by a shortage of labor. The average of the ore treated for the first 6 months of 1912 was just under 12 grm. of gold per ton. An extraction of 92 per cent. was obtained. The St. John del Rey Mining Co., Ltd., has an estimated ore reserve of 1,000,000 tons. During the year ended Feb. 29, 1912, this company sent 192,600 tons of gold ore to the 120-stamp mill, recovering 29s. 9d. per ton, by amalgamation, and 16s. 1d. by cyanidation. The lowest working of this property is 4900 ft. below the surface and the eighteenth level, at a vertical depth of 5500 ft. was expected to be reached early in 1913. An American expedition arrived in September to test reported gold-dredging ground in the State of Goyaz.

Exports of gold in bars amounted to 3641.25 kg. ($1,954,674) in 1910; 4289.63 kg. ($2,272, 631) in 1911; and 4026.78 kg. ($2,116,200) in 1912. Almost the whole export goes to Great Britain.

*Bolivia.*—Although this country, 20 years ago, held second place among the world's silver producers, and in spite of abundant reserves of medium-grade ore, the silver output continues to diminish, as shown by the following figures representing kilograms of fine silver: 1908, 156,482; 1909, 155,360; 1910, 142,977; 1911, 127,900; 1912, 123,939 kg.

*Canada.*—The gold production of 1912 is estimated at approximately $12,559,443, which compared with the 1911 production, $9,781,077, shows an increase of $2,778,366.

The Yukon placer production in 1912 is estimated at $5,540,000 as against $4,580,000 in 1911, the total exports on which royalty was paid during the calender year, according to the records of the Department of Interior, being 335,016 oz. in 1912, and 277,431 oz. in 1911. The British Columbia production in 1912 was $5,167,390, of which the placer production was $485,000, smelter recoveries and bullion obtained from milling ores being valued at $4,667,390. The main feature of the year was the large increase from Ontario due to the commencement of operations by several mills in the Porcupine district, the Province producing $1,745,292 as against $42,625 in 1911. In Quebec there is a small amount credited to the pyritic ores as well as a small recovery from Beauce County, and Nova Scotia shows a further decrease.

The exports of gold-bearing dust, nuggets, gold in ore, etc., in 1912, were valued at $10,014,654. Gold in bars, blocks, ingots, etc., was imported in 1912 to the value of $1,096,546.

There was a decrease of 627,334 oz. in the silver production in 1912, which was 31,931,710 fine oz., but due to the increased price, the value shows an increase from $17,355,272 in 1911 to $19,425,656 in 1912 or $2,078,384. Of the 1912 production 29,190,122 oz. was from Ontario, 2,651,118 oz. from British Columbia, the increases being from British Columbia and the Yukon. For British Columbia the figures represent the recovery as mill bullion or silver contained in smelter products, while for Ontario the figures represent the total silver content of ore and concentrates shipped, less 5 per cent. allowed for smelter losses, together with bullion shipments. The total shipments of ore and concentrates from the Cobalt district and adjacent mines were about 29,116 tons, containing approximately 25, 684,082 oz., in addition to which 4,773,878 oz. were shipped as bullion. There was also a small silver recovery from the gold ores of Ontario. In Quebec the silver was derived from the pyritic ores of the eastern townships.

The exports of silver in ore, etc., as reported by the Customs Department, were 34,911,922 oz., valued at $19,494,416. There was also an importation of silver in bars, blocks, sheets, etc., valued at $822,020.

British Columbia (By E. Jacobs).—The production of gold was smaller than was expected, as to both placer and lode gold. The 1911 yield of placer gold was the lowest in 17 years; that for 1912 was an increase of about 3500 oz. Atlin district was first, with a yield of $260,000, and Cariboo next with $200,000. All other parts of the province together rave $15,000. The total value of placer gold was $485,000, against

$426,000 in 1911. Boundary district, including Hedley, Similkameen, made a net increase in lode gold of 15,000 oz., and Nelson about 3000 oz. Rossland production was about the same as in 1911, while the Coast district showed a decrease. The total production is estimated at 250,000 oz., as compared with 268,000 in 1910.

The output of silver, 2,651,118 oz., is the highest in the past five years. Nearly one-half came from Ainsworth-Slocum mines, while about 400,000 oz. was from Boundary district mines, in the ores of which both gold and silver are associated with copper, though the last is the metal of chief value. East Kootenay silver production is estimated at between 350,000 and 400,000 oz., that of Coast mines at rather more than 100,000 oz., and from Rossland about 90,000 oz.

Ontario (By Thomas W. Gibson).—The gold output of Ontario in 1912 amounted to $1,745,292, or four times as much as in any previous year. The bulk of the output came from Porcupine, where the principal mines are the Hollinger and Dome. The latter began to produce early in the year, and the Hollinger in July. The future of Porcupine depends largely upon the success of these two properties, which, from the first, have been vigorously operated and well managed.

At both mines, the gold is found in quartz, but the ore occurrences are dissimilar. At the Dome the gold outcrops in large masses or so-called "domes," intermixed with schist which is also gold bearing. Consequently the open-cut method is followed, and both quartz and schist are milled. The Hollinger, on the other hand, is characterized by well-defined veins, upon which shafts are sunk and levels run in the ordinary way. The deepest working level is at 300 ft. This mine began paying dividends in November, and the management expects to distribute $40,000 monthly.

The Jupiter, McIntyre, Vipond, and other smaller mines are also now producing, or are preparing to do so. In 1912, a branch line of the Timiskaming & Northern Ontario Ry. was built into Timmins, the townsite of the Hollinger. Power is transmitted by electricity from Sandy Falls and Wawaitan Falls on the Mattagami River.

Other gold camps in northern Ontario being developed are Swastika, Munro and Larder Lake, but as yet the actual production from these has been small. The St. Anthony mine, at Sturgeon Lake, continued to yield, and the old Cordova mine, in Hastings County, was reopened.

The silver mines of Cobalt enjoyed in 1912 a productive and prosperous year. Their gross output as reported by the Ontario Bureau of Mines, was 30,260,635 oz., or 1,250,000 oz. less than in 1911, but owing to the higher prices for silver the value was much greater, or $17,455,000. The chief producers were: Nipissing, Coniagas, Crown Reserve, McKinley-

Darragh-Savage, Buffalo, Kerr Lake, La Rose, Cobalt Townsite, Cobalt Lake, O'Brien, Wetlauffer-Lorrain, Trethewey, Timiskaming, Beaver, and in Gowganda, Miller Lake-O'Brien and Mann. There was a revival of interest in the Gowganda and Elk Lake districts, and serious work is in progress at several properties in the latter region, into which a branch of the T. & N. O. Ry. is now being built.

The tendency of the Cobalt camp toward home refining is becoming marked, and a number of the mines now have plants for producing merchantable bars. The Nipissing mine, after much experimenting, brought into use a novel and highly efficient combination of amalgamation and cyanidation methods for the treatment of its high-grade ore, containing 2000 oz. of silver and upward per ton. The extraction of silver is practically complete and the loss of mercury trifling. The mill was devised by Messrs. Butters and Clevenger, and the results obtained in dealing with these complex and refractory ores, containing as they do as much as 40 per cent. arsenic, together with nickel, cobalt, antimony, etc., stamps it as a triumph of metallurgy.

Several new and important veins were discovered in the camp during the year. The Casey-Cobalt mine, situated on an outlying area of conglomerate about 15 miles from Cobalt proper, has proved to contain a rich deposit of silver. At the Beaver mine, the shaft was put down through the Keewatin to the underlying diabase, and good ore found in the latter. Cobalt Lake, for which over $1,000,000 was paid to the government, and which for a time was a disappointment, yielded a large quantity of silver during 1912. In the case of several of the mines paying royalty to the government, a lowering of the rate took place. This affected the Chambers-Ferland, Hargrave, Cobalt Townsite and O'Brien mines. No important extensions of silver-bearing territory were made in 1912. About $8,000,000 was distributed by the mines in dividends.

The Nipissing Mines Co. states in its annual report for 1912 that the cost of producing 4,688,260 oz. of silver was 17.39 cents per oz. This cost was made up of 12.08 cents for general operating expenses including explorations, sorting, loading, etc.; 2.12 cents for milling high-grade ore, 0.66 cent for milling low-grade ore, 1.12 cent for depreciation, 0.87 cent for custom milling, 1.31 cent for marketing, 0.3 cent for corporation expense, a total of 18.46 cents less a credit of 1.07 cent for rents and interest received. The cost of production equaled 28.14 per cent. of the gross value of the silver produced.

Prospecting is now carried on by a hydraulic plant recently installed. Water is furnished by a turbine pump situated on Cobalt Lake, throwing 4800 gal. per min. under a 415-ft. head at the pump and is directly connected to a 650-h.p. high-speed motor. The operation consists of stripping

the surface of soil and boulders by a stream of water directed through a 3.5 or 4-in. nozzle with 121 lb. pressure at the nozzle. The plant was in operation from May 8 to Nov. 29, 1912, without serious interruption, for 16 hours per day. During this time 33.2 acres of ground were cleared of soil, the average depth being 4.75 ft. Referring to the statement of expenses the cost of hydraulicking and clearing land is given at $19,292. This would indicate that the average cost was $581 per acre or 7.56 cents per cubic yard of material removed.

Reserves at the end of 1912 are estimated at 9,643,338 oz. of silver, as against 7,883,792 oz. at the end of 1911. Of this amount 3304 tons of high-grade ore are estimated to contain 5,491,343 oz. of silver, while 185,173 of mill rock are estimated to contain 4,151,995 oz. Thus, ore reserves were added to during 1912 by more than 1,750,000 oz.

By the completion of the low-grade mill, and a sampling plant for high-grade ore, the company is now entirely independent of outside companies for the treatment of all grades of its ore. Practically all its silver is now shipped as fine bullion. A contract has also been arranged for the sale of the residue from the high-grade mill, whereby a fair price is received for the cobalt content.

Yukon Territory.—The most interesting feature of the Yukon Gold Co. report for 1912 relates to the acquisition of dredging ground in the Iditarod district. There were secured, either by working agreement or by purchase, 24 claims, which gives practical control of Flat Creek, the principal producing creek of the district. The dredgable area is reported to contain about 5,500,000 cu. yd., much of which is thawed, and extends about 4 miles from the head of the creek to the mouth.

Dredge No. 7 completed its work on Upper Hunker Creek, in the Dawson district, in October, 1911, and was moved to Iditarod, where it was rebuilt on the upper end of Flat Creek, on the Marietta claim. A 300-kw. plant was built near the Bonanza claim on the same creek, to furnish the dredge with power. The installation consists of a steam-driven turbine, direct-connected to a 4400-volt generator, a boiler plant and a transmission line two miles in length. The plant began operations on Aug. 15, 1912, and handled 172,333 cu. yd., producing $404,040 worth of gold at a total cost of $79,114, or a cost per yard of 45.91 cents on $2.34 gravel. On Oct. 29, operations ceased for the winter.

The accompanying table summarizes the results for the year. From the net operating profit as shown, there were deducted $692,995 for royalties paid; $577,146 for amortization and deferred charges; $378,686 for interest, general expenses and examinations, or $1,648,827 as a total.

1912 OPERATIONS OF YUKON GOLD CO.

| Assets. | 1912. | Liabilities. | 1912. |
|---|---|---|---|
| Property and investments | $12,026,120 | Capital stock | $17,500,000 |
| Equipment | 6,935,801 | Guggenheim Explo. Co. | 2,524,972 |
| Deferred charges | 441,279 | Bills and accts. payable | 202,272 |
| Supplies and materials | 879,292 | Depreciation | 568,893 |
| Advanced royalties | 340,604 | Surplus | *409,275 |
| Accounts collectable | 502,965 | | |
| Cash | 97,351 | Total | $21,223,414 |
| Total | $21,223,414 | | |

* Surplus is after payment of dividend Dec. 31.

| Operation. | Gross Production. | Working Costs. | Operating Gain. |
|---|---|---|---|
| Dawson dredges | $3,346,027 | $1,580,290 | $1,765,737 |
| Dawson hydraulicking | 629,044 | 277,953 | 351,091 |
| Iditarod dredge | 404,040 | 79,114 | 324,926 |
| Miscellaneous | 484,337 | 204,672 | 279,666 |
| Total | $4,863,448 | $2,142,029 | $2,721,420 |

In the Klondike district, some few purchases of outstanding claims were made and some additions in the way of pipe-lines, cuts and sluices made to the hydraulic equipment. An operating season of 172 days was obtained, from early in May until Oct. 24, for the Dawson dredges, during which time there were mined 5,157,280 cu. yd. of an average value of 64.88 cents, at a cost of 30.64 cents per yard. The yardage for the year was increased by about a million, and the gross production about $674,181. The value per yard increased 0.53 cents and the cost decreased 4.79 cents per yard. Of the area mined, 509,544 sq. yd., or 73.58 per cent., had to be thawed.

The hydraulic mines handled 2,967,750 cu. yd. of gravel, averaging about 21.2 cents per yard. The increases over the previous year were 842,000 yd. and $195,000. The value per yard increased slightly and the cost was reduced from 15.5 cents to 9.37 cents per yard. The hydraulic water system is now in excellent condition.

Operations in the southern part of Yukon Territory during 1912 are thus described by W. C. Sime, territorial assayer. The figures cover the year ended March 1, 1913.

The greatest amount of work has been done on the Pueblo mine. The vertical main shaft was sunk to a depth of 123 ft. At the 200-ft. level a station was cut and an ore pocket put in, and this level is now being rapidly opened up. To date 38,750 tons of ore have been shipped to the smelter (at Tacoma, Wash.). On the Valerie and the Grafter mines a considerable amount of development work has been done, each having a shaft down over 200 ft.

In the Windy Arm district several shafts have been sunk on the various claims. The ore consists chiefly of argentiferous galena associated with a considerable amount of pyrite, arsenopyrite, and zinc blende. Several small shipments have been made to the smelter, averaging $80 to $90 per ton in gold, silver, and lead.

The Big Thing mine was worked steadily for several months and then shut down in June, 1912, the reason assigned being the high cost of getting in supplies and machinery. The amount of work done in tunnels, upraises, and drifts was about 1800 ft. There are in sight some 60,000 tons of ore that is said to average $11 per ton and at least 400,000 tons averaging $6 to $8 per ton. The ore consists of quartz associated with galenite, pyrite, stibnite, and arsenopyrite.

The Whirlwind group of claims has been worked continuously for the past 12 months. The owners crosscut the ledge by a 170-ft. tunnel and drifted along the vein about the same distance. The vein averages 4 to 5 ft. in width and is composed of quartz with occasional small quantities of galena, and averages about $30 to the ton in gold and silver. At present there are over 50,000 tons of ore in sight.

The Buffalo Hump group was prospected and developed with very good results during the past summer. The veins on this group consist of quartz associated with small quantities of galena, and often show free gold; sylvanite and telluric ocher have also been found. A good road has been built by the Government to this property.

*Colombia.*—The chief mining interest in Colombia lies in the alluvial deposits of gold in the valley of the Magdalena, and of gold and platinum in the valleys of the Atrato and the San Juan. Two dredges were in operation in 1912, the "Pochet," a 3-cu. ft., Worth-Conrad steam-driven boat on the Nechi, a tributary of the Magdalena, and the "Certigue," a 5-cu. ft., steam-driven Empire dredge on the Certigue River, a tributary of the Atrato above Quibdo.

The Breitung Mines Corporation has options on several tracts on the Cauca and Nechi Rivers, and did considerable drilling in 1912. Lewisohn Brothers prospected an area in the Atrato Valley early in 1912, but evidently with unsatisfactory results. The Gold Fields American Development Co., Ltd., sent out a large party late in 1912, to drill several claims near Novita, on the Condoto River, a tributary of the San Juan. Two other drilling parties representing American capital expect to commence operations on the Nechi and Cauca Rivers early in 1913. On the upper Porce River, the McGuire Brothers operated an Empire hydraulic elevator with encouraging results. The Guadaloupe and Porce Mining Co., composed principally of Denver, Colo., men, was reported to have installed an Evans hydraulic elevator.

El Recreo mine, in the department of Tolima, produced 860 oz. of bullion from Sept. 1, 1911, to Aug. 31, 1912. This mine has a wooden stamp mill of nine stamps. The ore treated was all from development work. In the southern part of the republic, near the boundary of Ecuador, are several gold quartz mines, which report encouraging operations. Here the Gualcala Mines Co., an American concern, operated an all-sliming cyanide plant in 1912.

The U.S. consul at Barranquilla reports that the Colombian Government has ordered the reopening of the government mint at Medellin for the coinage of gold. It is presumed this will materially affect the export of gold dust and bars from Colombia.

(By Silas Wright).—The total production of gold, silver and platinum of the Department of Antioquia in 1912 was approximately $3,500,000, somewhat less than in previous years. This total represents principally gold from both quartz and placer operations, throughout the entire Department of Antioquia proper, which includes the mining districts of Manizales as well, although this now is part of the Department of Caldas. The greater part of this gold is shipped to New York and to London, monthly shipments of gold bars from Medellin being from $150,000 to $300,000. The quartz regions of Antioquia are as a rule in the higher and more healthful regions, while the placers are lower down along the rich alluvial streams where often unhealthy conditions prevail. Platinum is found in paying quantities only in the Atrato region, and it is mined by the natives in a desultory way by washing the sands and river gravels. Silver is mined only as found with gold in certain places, as at the Zancudo mines.

So far, American capital has been invested almost wholly in placers, while English capital seems to have preferred quartz properties. Of the principal American mining enterprises in Antioquia, the following may be mentioned: Pato Mining Co., on the Nechi River, just above the town of Zaragosa, the head of navigation of the Nechi River. There a hydroelectric power plant and an 8-cu ft. bucket dredge was nearing completion at the end of 1912. This plant is being built under the direction of the same interests that control the Oroville Dredging Co., of California. The area of this company's ground is considerable and is thoroughly proved.

In the Amalfi region, in the vicinity of the Porce River, the following American companies are now putting in modern hydraulic plants to work the high alluvials of that and other adjacent streams. The Viborita Hydraulic Mining Co. has about completed a 1000-ft. tunnel in hard rock which is to be used for dumping the mine débris into the Porce River low, and operations with hydraulic giants have already been started

Vallecitos Hydraulic Gold Mining Co. is at present constructing a

long ditch and otherwise equipping the property with a modern plant, which should be in operation also this year. The San Benigno Hydraulic Mining Co. is also reëquipping an old hydraulic plant on a larger scale, and should also be in operation soon.

On the Porce River, which of late years has been the best gold producer, and is distant 50 miles from Medellin, several hydraulic-elevator plants are in operation and under construction. Of these, two are American enterprises, viz.: La Clara Mines, rented from the owner by the McGuire Bros., under whose management the plant is perhaps the best of its kind in Antioquia, consisting of about 15,000 ft. of new hydraulic piping and three elevators. With an old outfit of one single pump, they took out last spring 145 lb. of gold in three months. The Hormiguero Hydraulic Mining Co. has been operated for several years with varying results, the last year being the best, when 100 lb. of gold were recovered. This mine adjoins La Clara mine on the lower side.

Of the other Porce River mines, which are native holdings altogether, there is one known as the Gavino which attracted attention for its exceptional richness while it lasted. It is situated on a small bar in the Porce River, just below its junction with the Rio Grande. During the last two years that this mine has been in operation, about $170,000 has been taken out, and the deposit will be worked out in another year. At the present rate of equipment of new plants on modern systems, the Porce River, in this district, will be worked out within the next 5 or 10 years, and the river below this region runs through too much of a gorge to enable mining operations to be carried on. Good mining grounds remain still unworked on tributaries of the Porce River, such, for instance, as the Rio Grande, where options on placers are already being taken up by Americans.

Any mining venture in Antioquia requires considerable capital. Most of the mining grounds and veins have been located, and one must, therefore, deal with the owners, and the prices asked are far above what mere prospects are worth. With the completion of the Antioquia R. R., connecting the Magdalena River with Medellin, and running along part of the Porce River, together with the building of new river steamers for the Cauca, Nechi and Atrato Rivers, the mining regions will become more easily accessible and freight transportation less costly.

*Congo.*—Gold was discovered several years ago in northeastern Congo near the border line, but as the territory had not been opened to free trade, the deposits were claimed and operated by the government. These mines, which have been rapidly developed, are known as the Kilo mines, and employ 2000 to 3000 natives. The State has gold mines also at Mombisa and Zodi, near which are the Kanwa mines, owned and

operated by the Société Internationale Forestière et Minière du Congo (a Belgian-American company, the stock of which was evenly divided between Belgian and American interests at the time of formation) and managed exclusively by experienced Americans. The output of these mines is about 10 kg. a month, but this will be increased as new machinery is installed. Exports of gold during recent years have been as follows: 1905, 61 kg.; 1906, 212 kg.; 1907, 322 kg.; 1908, 311 kg.; 1909, 674 kg.; 1910, 755 kg.; 1911, 906 kg.

The feature of the gold industry in 1912 was the successful advance of placer mining. The total production for 1912 amounted to 1045 kg. crude gold, valued at $625,000. The State budget for 1913 for the operation and prospecting of gold mines was $477,750. In the first three months of 1912, 192 kg. of gold were produced at Kilo, the chief state placer, whence the output for the whole year is estimated at 750 kg. A description of the geology near Kilo is given by H. Buttenbach.[1] At Moto, 325 miles southeast of Stanleyville, sluicing began in Nov., 1911. The production in 1912 was estimated at 200 kg. The gravel runs 90 cents to $1.20 per yard. The value of the gravel in sight in August, 1912, is estimated at $720,000. Nebula-Bokwama state placer was exhausted in 1912, producing only 27 kg. The placer Tele, nearby, produced 70 kg. in 1912.

*Costa Rica.*—The Abangarez Goldfields was the main factor in the mineral production of Costa Rica in 1912. The Boston mine was closed early in the year and has not been reopened. The low recovery obtained at the Abangarez plant has resulted in numerous experiments and the system of treatment will doubtless soon be changed. The new 2500-h.p. hydro-electric plant was completed and work is well along on the new mill.

The new 100-ton addition to the cyanide plant at the Aguacate mines was to have been in operation by Jan. 1, 1913. The La Union slimes plant operated successfully in 1912. This company will show a substantial increase over 1911.

The export of gold and silver during each of the past five years was as follows (nearly all shipped to the United States): 1907, $520,056; 1908, $673,188; 1909, $792,847; 1910, $811,186; 1911, $1,190,406.

*East Africa, Portuguese.*—The territory of the Compañia de Moçambique is little prospected and little developed. The greatest amount of work has been done in the neighborhood of Macquece (Massi Kessi), where ancient, alluvial gold workings exist. This place is on the railroad, 183 miles from the port of Beira; no duty is charged on mining supplies. The company receives a royalty varying from 1 to 4 per cent. on the value of

[1] *Annales de la Société Géologiqued e Belgique*, T. XXXVI, *Bull.*, 1909, p. 79–86.

the gross output of properties producing less than 800 oz. of fine gold monthly; and operators producing more than 800 oz. pay a tax of 10 per cent. on net profit.

In 1911 the lode mines produced about $60,000 worth of gold, the chief contributors being the Guy Fawkes, the Chimezi and Rhodes Banket and the Central Welcome. The report of the Compañia de Mocambique states that while mining declined somewhat in 1911, due to the suspension of operations by the Edmundian copper mine and the Braganca-Richmond gold mine, on the other hand, 14 stamps were added to the total number on gold properties, bringing the total up to 85, and a new company, the Andrada Mines, Ltd., was formed and took over the claims of the Mozambique Mines, Ltd. This company is planning development and exploration work on a large scale, including prospecting of alluvial deposits. It is stated that two dredges will be constructed. Exports of gold from Portugese East Africa during 1912 are reported by the U. S. Consul at Lourenço Marques as $4468 from Chinde, and $53,424 from Beira.

*Ecuador.*—At present the only important gold-mining operation belongs to the South American Development Co., an American corporation. It is understood that the company operated throughout 1912. The West Coast Gold Dredging & Rubber Co. proposes to erect two dredges on their property in the northern part of the Republic during 1913, one near the mouth of the Cachadi River and one further up the river, near San Jose.

The Zaruma mining district, the development of which has been checked by lack of transportation, will be tapped by the railway from Machala to Loja, the concession for which was granted in 1912.

*Federated Malay States.*—Pahang is by far the most important gold-producing state, and Perak contributes to a small extent. Negri Sembilan in late years has practically ceased to produce gold, and the only other state, Selangor, never produced any. In Pahang most of the gold production comes from the Raub Australian Gold Mining Co., at Raub. There are also alluvial workings in the Kuala Lipis district. None of the workings is more than 500 ft. in depth, excepting the Raub mine. There air-drills are used to some extent. The ore is crushed in a 40-stamp mill; concentrating tables follow, but the cyanide equipment has been abandoned as unprofitable. The power used is transmitted 6 miles from a hydro-electric station in the mountains.

The combined output of the Federation in recent years has been as follows, in fine ounces (the reported crude bullion having a value of £3 17*s.*, 6*d*, per ounce, or 0.912 fine): 1909, 14,810 oz.; 1910, 15,287 oz.; 1911, 8414 oz.; 1912 (partly est.), 12,866 oz.

*Guatemala.*—The thorough exploration of the country undertaken by

the Guatemala Mining & Development Co., was practically complete and nothing of promise other than a marble deposit was discovered. Some work was done by this company, and by Minor C. Keith at the Conception silver mines, but with indifferent results. The Chiantla Mining & Smelting Co. received a small lead-silver furnace, which is to be operated at the property, near Chiantla. The Potts & Knight placer property, at Las Quebradas, continued a steady producer as it has for the last 30 years. Numerous efforts have been made to dispose of this property to parties able to install modern machinery, which would materially increase the output.

*Guiana, British.*—A production of 49,607 oz. crude gold (42,563 oz. fine) is reported for the fiscal year ended June 30, 1912. This merely continues the steady decrease which has been recorded since 1893–94, when gold production reached its maximum of 138,527 oz. Two dredging companies continued fairly successful operations. The Guiana Gold Co., Ltd., for the year showed a total production of about 7409 oz., and declared a dividend of 10 per cent. The Minnehaha Development Co., Ltd. showed a total production of 2030 oz., an increase over the previous year. A protracted drought interfered with the operations of both dredging companies, but it is stated that their success stimulated a demand for dredging ground, and applications for concessions were received by the government.

No hydraulicking was done in the period reported on, the Tassawini Mining Co., Ltd., having gone into liquidation. The lode-mining industry was relieved of a burden of 70 cents per oz. royalty. Operations were therefore continued on the Barima mine. For the last six months of 1911, this mine showed a production of 1161 oz. from 5757 tons, making a profit of $1528, or 28 cents per ton; out of this profit the Government takes 5 per cent.

The outputs of crude gold in recent years have been as follows: 1908–9, 73,273 oz.; 1909–10, 61,574 oz.; 1910–11, 54,064 oz. This gold is approximately 0.858 fine.

*Guiana, Dutch.*—The production of crude gold in Dutch Guiana for the year ended Sept. 30, 1912, was 518,957 grm. (433,848 grm. or 13,948 oz. fine gold), a decrease of 157,629 grm. from the previous year. This output came mainly from prospectors and a few companies operating both quartz and alluvial properties. There are two gold-bearing zones in Dutch Guiana: the one nearest the sea coast is situated in the northwest district at the head of the rivers which flow into the Saramacca on the South and the Atlantic Ocean on the north, the dividing ridge being the Nassau Mountains. The second zone stretches across the country ›m northwest to southeast, beginning in the Corantyne and Nickerie

Rivers, from thence to Saramacca across the Surinam to the Upper Sara Creek and across the Tappenanoi, Gonini and Maroni. During 1912 there were over 5000 laborers engaged in the several districts. Late in September an expedition arrived to prospect the alluvial property held by the Olga Exploration Co., Ltd., of London.

*Honduras.*—The New York & Honduras Rosario Mining Co. continued to be the chief producer. A total of 39,258 tons of silver ore was treated. The new cyanide plant, having a capacity of 200 to 250 tons per day, went into commission in 1912. With the old equipment little ore running under $25 per ton was touched, while with the new plant the management claims that $15 ore will be the average for the next few years.

The report of this company for the year ended Sept. 30, 1912, gives a total ore reserve of 127,850 tons in place in addition to 164,216 tons which contain about 29 per cent. waste. Its value per ton, as delivered to the Rosario mill, is $17.65, U. S. currency. Exploration work performed on the various veins and crosscuts amounted to 10,282 ft., or less by about 3000 ft. than that done during the previous year, due principally to a prolonged drought, during which the compressor plant could not be operated at full capacity. Geologic study has gone far toward proving that the theory confining ore deposits to the andesites, is not true. The ore extends into the overlying rhyolites, which cover a larger area, thus materially increasing the life of the mine.

A total of 39,258 dry tons of ore were delivered by the mine, as against 35,813 in the previous year; 28,828 tons were sent to the old mill, and the rest, 10,429 tons, went to the new mill, which was put into commission in July. The milling cost at the old mill was 2.33 pesos per ton for labor and 6.72 pesos per ton for supplies, a total of 9.05, the peso being valued at about 40 cents, U. S. currency. The new mill has not been in operation long enough to supply definite cost data. The old mill was operated without serious interruption for 24 years. The total operating cost in pesos is as follows: Mine, 18.98; tramway, 1.25; mill (average of old and new), 8.65; surface, 5.98; a total of 34.86, or about $13.95, U. S. currency.

The total production of gold and silver was valued at $795,795. Total expenditures were $615,904, leaving a net income of $178,890. A cash dividend of $30,000 was declared and an additional $500,000 in stock was divided.

A grant has been made for the construction of a railway to connect Agalteca with the Atlantic Coast by way of the Sulaco Valley. This will open up the copper-gold district at Minas de Oro, the operation of which has been curtailed.

*India.*—According to the latest official report available, the total output of gold in 1911 was 583,567 oz., worth £2,238,143, equivalent

to 526,622 fine oz., an increase of 1.62 per cent. over the output of 1910, which was equivelent to 518,010 oz. fine. Most of the increase occurred in the Mysore field. At the same time, the new Anantapur field in Madras more than doubled its output of 1910.

The report of the Mysore Gold Mining Co., for the year 1912 states that 299,660 tons of ore were crushed, yielding by amalgamation 200,662 oz. of gold bullion, or 0.67 oz. per ton. Cyanidation of 247,340 tons of tailings, and 7476 tons of slime yielded a further output of 31,100 oz. of bullion, giving a total yield of 231,726 oz. equivalent to 212,724 oz. fine gold, selling for £904,079. Deducting royalties of £51,277, and adding miscellaneous receipts brought the total net income to £860,878; expenses were £374,033, leaving net profits of £513,845.

"Air blasts" in the Mysore mines are becoming a serious feature. In 1912 of a total of 88 deaths, 41 were due to this phenomenon, and in one such blast 21 men were killed. A seismological observatory is now in operation at the mine, seeking to discover the causes and predict the occurrence of the disturbances.

The output of silver in Burma in 1911 was 103,850 oz. valued at $55,308, with an additional production of 8218 tons of silver-lead ore, worth $23,408. The gold yield of 1911 was 6422 oz., worth $118,590; most of it was produced by the Burma Gold Dredging Co., operating four Australian dredges on the Irrawaddy River, near Myitkyina, in Upper Burma.

Imports of gold into India have been a pronounced feature of the world's interchange of precious metal during the past three years. Imports during 1912 were about £23,100,000 while exports were only about £2,500,000. Statistics of recent years, as compiled by the Director of the U. S. Mint, are given in the following table:

GOLD AND SILVER MOVEMENT OF INDIA.
(In fine ounces.)

| | Gold. | | | Silver. | | |
|---|---|---|---|---|---|---|
| | 1909. | 1910. | 1911. | 1909. | 1910. | 1911. |
| Imports | 2,446,152 | 4,389,653 | 5,772,398 | 80,297,575 | 65,290,456 | 74,870,977 |
| Exports | (a)384,232 | (a)683,340 | 645,139 | 13,283,964 | 15,101,455 | 33,241,396 |
| Net Imports | 1,861,920 | 3,706,313 | 5,127,259 | 67,013,611 | 50,189,001 | 41,629,581 |
| Domestic | 374,816 | 518,010 | 526,622 | ..... | ..... | 104,323 |
| Total Metal | 2,436,716 | 4,224,323 | 5,653,881 | ..... | ..... | 41,733,904 |

Imports of gold are about equally divided between bullion and British with a small additional amount of other coin. All this bullion,

except about 580,000 oz. annually re-exported, is either hoarded, or used in the arts, since no gold is coined in the Indian mints. The principal imports come in the form of bullion from United Kingdom and Australia, and in coin from Egypt. The new silver coined in India during 1911 included $6,424,523 worth for local use, and $32,073,400 worth for foreign circulation. Old silver coins to the value of $6,530,000 were received at the mints for recoinage during 1911.

*Japan.*—The production of gold in 1911 was 150,541 oz., which, if pure, had a value of $3,111,675. Figures for 1912 are not available, but assuming a repetition of the prevailing rate of annual increase, the output of 1912 was probably 160,000 oz. The silver production of 1911 was 4,438,037 oz., of an estimated value of $2,365,473. The output for 1912 is estimated at 4,500,000 oz. The production of Formosa in 1911 included 1656.6 kg. of gold ($1,100,877) and 1852.2 kg. of silver ($31,746).

The following data are from the U. S. consul at Nagasaki. The Hasami gold mines in Nagasaki Prefecture installed some modern machinery about 2 years ago and increased their output for 1911 (which amounted to $77,400) by about 50 per cent. over that of the preceding year. The Taiono gold mines in Oita Prefecture produce about 2400 oz. annually, the Urushi mine in Kagoshima Prefecture 1200 oz., the Okuchi and Ushio mines in Kagoshima each about 4800 oz. annually. The Yamagano gold mines in Kagoshima Prefecture are the largest producers of this metal in Kiushu, their output averaging over 15,600 oz. annually. The Serigano gold and silver mines located in the same Prefecture are also showing increased production, their output being over 6000 oz. per annum. The Kushikino gold and silver mines in Kagoshima Prefecture, which were taken over and are being developed by the Mitsui Busan Kaisha, are showing good results, and with the installation of modern machinery, which is being ordered from the United States, this group of mines will probably be one of the best gold producers in Japan, the estimated output being placed at 2400 oz. gold and 18,600 oz. silver monthly. Considerable interest has lately been centered in a new gold-mining district in the north-central part of Kiushu, near Kitakawachi, Fukuoka-ken.

*Korea.*—The Oriental Consolidated Mining Co., according to its annual report for the year ended June 30, 1912, treated 323,703 tons of ore averaging $5.86 per ton. This tonnage was made up of 321,343 tons of $5.87 ore from the company's mines, and 2360 tons of $4.33 ore from tributers. The total cost of production was $2.83, made up as follows: Mining, $1.62; transportation, 1 cent; milling, 50 cents; concentrate treatment, 20 cents; general expenses, 36 cents; development at outside mines, 5 cents, and construction expense, 9 cents per ton. These costs include 26,359 ft. of development work in the regular mines of the

company and 4242 ft. on outside properties, or a total of 30,601 ft. on the concession. A statement of cyanide expense shows that 49,715 tons were treated at a cost of $1.70 per ton cyanided.

Total exports of gold bullion and specie from Korea in 1912 were valued at $5,041,867, a decrease of $1,477,906 as compared with 1911. Imports of the same were valued at $733,760 in 1912, a decrease of $1,626,384 from 1911.

*Mexico.*—Mining was conducted at a disadvantage in some parts of Mexico during 1912, owing to the depredations of roving groups of bandits, operating under the guise of political revolutionists. These bands were especially active in the states of Sonora, Chihuahua, Coahuila, Durango and Zacatecas, and the region south of the City of Mexico. In the north, mining operations were chiefly curtailed because of the destruction of railroad property, which interfered with the shipment of ore and bullion and the delivery of fuel.

As to actual interference of the revolutionary disturbances with production, this was probably most marked in the case of the isolated gold and silver properties; the larger camps, such as El Oro, Pachuca, Guanajuato, where there was a considerable number of foreigners, were not seriously troubled by revolutionary disturbances nor by the depredations of roving bandits. Smelting operations in the interior were interrupted repeatedly, owing to shortage of fuel and ore supplies, due to the tearing up of railway tracks and the destruction of bridges.

PRODUCTION OF GOLD AND SILVER IN MEXICO.
(Fiscal years ending June 30.)

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Kilograms. | Pesos. | Kilograms. | Pesos. |
| [illegible] | 13,810 | 18,413,381 | 1,816,605 | 74,326,406 |
| [illegible] | 14,706 | 19,607,967 | 1,772,724 | 72,530,983 |
| [illegible] | 14,904 | 19,872,148 | 2,023,922 | 82,808,783 |
| [illegible] | 17,082 | 22,775,815 | 2,013,383 | 82,377,546 |
| [illegible] | 21,306 | 28,407,313 | 1,931,985 | 79,047,148 |
| [illegible] | 27,307 | 36,409,368 | 1,849,956 | 75,605,605 |
| [illegible] | 27,423 | 36,563,898 | 1,756,704 | 77,088,827 |
| [illegible] | 30,395 | 40,527,185 | 2,151,014 | 85,366,904 |
| [illegible] | 33,661 | 44,881,621 | 2,291,261 | 77,076,097 |
| [illegible] | 36,222 | 48,295,508 | 2,257,363 | 76,371,884 |
| [illegible] | 37,112 | 49,481,956 | 2,305,094 | 80,878,729 |
| [illegible] | 36,415 | 48,553,632 | 2,493,731 | 89,628,435 |

[illegible]—1 kg. = 32.15 oz. 1 Peso = $0.50 U. S. currency.

[illegible] estimated production of the Pachuca and Real del Monte mines for [illegible] 800,000 tons, of an average grade of 22 oz. silver and 0.1 oz. gold, [illegible]al average value of which was $15 per ton; 88.5 per cent. of this [illegible] covered. These figu[illegible]er ore milled locally and treated in

cyanide plants, the figures for high-grade ores shipped to smelters being unavailable and unimportant.

The Real del Monte Company had its two mills in full operation, treating about 40,000 tons of ore per month. Santa Gertrudis, which is the only company that does not remove 15 or 20 per cent. of the valuable constituents of the ore previous to cyaniding, treated about 23,000 tons per month, but the capacity is to be increased to 28,000 tons. The La Blanca Company treated about 8000 tons per month, but this will be increased to 12,000. Reports indicate that a reduced production may be expected from the San Rafael Company.

Two American companies, the Blaisdell Coscotitlan Syndicate and the Popolo Tailings Co., retreated by the cyanide process the tailings which have accumulated during the last 150 years to the south of Pachuca. These tailings carry a fair amount of gold, owing to the low recovery of this metal obtained in olden times by the patio treatment of ores.

El Chico camp is showing signs of renewed activity on a limited scale, a small custom mill being in process of erection. The production of Pachuca district should reach its maximum during the coming year, and including concentrates should approximate 20,000,000 oz. of silver and 90,000 oz. of gold. The district has been practically unaffected by revolutionary troubles. Duties on mining and milling machinery and supply imports were increased 5 per cent., Sept. 1, 1912, and were scheduled to be increased an additional 5 per cent. Jan. 1, 1913. These imports will add materially to the cost of equipment and operation in Mexico.

Las dos Estrellas, during 1912, crushed 500,600 tons of ore and recovered gold and silver to the value of 11,421,996 pesos; net profits were 6,093,164 pesos, or 200,000 pesos more than in the preceding year. New development has not been vigorously prosecuted during the last 2 years, but will now be resumed, dividends having been temporarily reduced to provide additional funds for that purpose. Reserves at the end of 1912 were estimated at 1,963,000 tons of average grade; the mine also contains 3,000,000 tons of low-grade ore.

Exports of gold in all forms during the calendar year 1912 amounted to 34,091.5 kg., consisting of 841 kg. contained in ore; 32,015 kg. in bullion; 1113 kg. in specie; 32.7 kg. in cyanide precipitate; and 89.8 kg. in sulphide material. The greater part of it comes to the United States; a little goes to Europe. Exports of silver during 1912 included 153,753 kg. in ore; 2,182,696 kg. in bullion; 220,987 kg. in specie; and 8,877 kg. in cyanide precipitate. Most of the silver too comes to the United States, though England takes about 500,000 kg. Exports of Mexican silver coins, on which an export tax is levied, were unusually heavy during the latter half of 1912, amounting to nearly 8,000,000

pesos, as compared with 714,000 pesos during the whole of the preceding fiscal year. Of the total production of silver in the fiscal year 1911-12, delivered to government offices, less than 2 per cent. was minted, all the rest being intended for export. No gold has been coined in Mexico for the last 2 years.

*Norway.*—Total output of silver in late years has been: 1910, 9196 kg.; 1911, 10,468 kg.; 1912, 9400 kg. The state mines at Kongsberg afford the main output, their production in 1912 having included 7036 kg. of bullion ($152,787) and 1230 kg. of silver in ore ($19,800). Expenses were $139,770. The relative outputs of the several state mines are: Samuel, 60 per cent.; Gottes Hülfe, 17 per cent.; Kongen, 15 per cent.; Gabe Gottes, 8 per cent. A recent commission recommended that efforts should be made to recover the long lost main silver vein in the Kongen mine, and this has now been found at a depth of about 912 m., running in a width of about 5 m., bearing both sorting ore and silver. A quantity of native silver is also reported to have been discovered in the mine. Moreover, the discovery is reported of two new and important silver-bearing veins, 5 to 8 m. wide, under the adit of the Gottes Hülfe mine, and about 625 m. below surface.

The Trollernd-Vinoren mines, north of Kongsberg but on the same mineral zone, are expected to begin production in 1913.

*Peru.*—The cyanide process was introduced in the gold region of Peru in 1912 at the new mill of the New Chuquitambo Gold Mines, Ltd., near Cerro de Pasco. The 40-stamp mill and cyanide plant made a monthly output of about 29 kg. of bullion from 3000 tons of ore. The copper present in the ore resulted in a high cyanide consumption and some details of the process are to be changed to overcome this trouble.

The first clean-up was made by the Aporoma Goldfields, Ltd., during 1912. The dry season early in the year interfered with this hydraulic operation, but results for the year were satisfactory. The Inambari Gold Dredging Concession, Ltd., of London, has raised the necessary capital to continue its work with the large dredge completed in 1912. The Peru Pot-Hole Gold Co., operating on the upper Maranon River, is to install a hydraulic plant in 1913.

The Caylloma silver mine, in Arequipa, maintained a steady production in 1912, and a cyanide plant is planned for the near future. The ore averages from 600 to 800 grm. of silver per ton, and the present recovery is about 60 per cent. E. E. Fernandini produced about 1,500,000 oz. of silver in his Huaracaca smeltery. The Doceña mine, at Cerro de Pasco, shipped about 8000 tons of silver ore per month to the local smeltery.

*Portugal.*—The output of silver in 1912 was 4646 kg., compared with 3667 kg. in 1911, and 6000 kg. in 1910.

*Rhodesia* (By Hugh F. Marriott).—The production of gold in 1912 did not show any marked advance. The tonnage treated was slightly less than that of the previous year, but the average per ton advanced from 33s. to 35s. 5d., and the total yield increased by 14,286 oz. The number of individual producers of gold in the latter part of the year totaled 175, in increase of 12 over 1911. Out of this total, 89 crushed about 10,500 tons per month or an average of under 120 tons per month each. Only six mines crushed 5000 tons or over per month. The biggest producers were the Lonely, the Globe & Phœnix, the Giant and the Eldorado, which together were responsible for about 40 per cent. of the total production of gold.

The Globe & Phœnix maintained its position as the leading producer in Rhodesia. In 1911, 71,802 tons were crushed, yielding £6 15s. 10d. per ton, and the net profit for the year after deducting all administration charges, depreciation, etc., amounted to £4 9s. 6d. per ton. During the first half of 1912, 33,824 tons were milled, yielding £7 3s. 10d. per ton, and the mine profit amounted to £5 7s. 8d. per ton. Making an allowance for administration and other charges on the same basis as in 1911, the net profit works out to about £4 13s. 5d. per ton. The total development at June 30, 1912, was 179,400 tons, of an estimated average value of £7 9s. 6d. per ton, a slight reduction in value as compared with the position at Dec. 31, 1911. A new sands plant was completed near the end of the year.

Although there were no noteworthy additions to the ranks of producing mines, a large amount of work was done on a few developing mines. During the nine months ended Sept. 30, 1912, the ore reserves of the Cam & Motor mines were increased from 607,664 tons, with a gold content of 46s., to 930,766 tons, containing gold to the value of a little over 45s. per ton. A 500-ton reduction plant was ordered. At the Falcon mine, where the ore contains gold and copper, the tonnage developed during the year to June 30, 1912, amounted to 311,000 tons, estimated to contain gold and copper to the average value of 58.4s. per ton. It was also estimated that further reserves amounting to about 330,000 tons were developed during the last half of 1912, but the value is not stated. The total reserves at Dec. 31, 1912, are estimated to amount to about 960,000 tons. A plant capable of treating 500 tons of ore per day is in course of erection.

At the Shamva mines, during the year ended Sept. 30, 1912, the ore reserves were increased from 1,554,761 tons, containing gold to the average value of 19.7s. per ton, to 2,203,912 tons, containing gold to the estimated total value of £2,323,513 or an average of 21s. per ton.

GOLD PRODUCTION OF SOUTHERN RHODESIA TO DECEMBER 31, 1912.

| | Tons Milled. | Gold, Oz. | Value. | Value per Ton. |
|---|---|---|---|---|
| Prior to Sept. 1, 1898 | (a) | 6,471 | £23,456 | ..... |
| Sept. 1, 1898, to June 30, 1899 | 81,841 | 48,847 | 177,072 | 43.26s. |
| July 1, 1899, to June 30, 1900 | 104,746 | 57,621 | 208,877 | 39.88 |
| July 1, 1900, to March 31, 1901 | 140,716 | 89,258 | 320,457 | 45.54 |
| Year ending March 31, 1902 | 249,667 | 180,910 | 640,661 | 51.32 |
| Year ending March 31, 1903 | 338,156 | 201,107 | 709,461 | 41.96 |
| Year ending March 31, 1904 | 516,747 | 234,693 | 845,359 | 32.71 |
| Year ending March 31, 1905 | 787,936 | 309,516 | 1,113,068 | 28.25 |
| Year ending March 31, 1906 | 1,100,609 | 435,019 | 1,556,741 | 28.28 |
| April 1, 1906, to December 31, 1906 | 1,051,908 | 426,333 | 1,531,481 | 29.10 |
| Year ending December 31, 1907 | 1,610,875 | 612,052 | 2,178,886 | 27.05 |
| Year ending December 31, 1908 | 1,819,230 | 606,962 | 2,526,006 | 27.77 |
| Year ending December 31, 1909 | 1,807,771 | 623,388 | 2,623,785 | 29.00 |
| Year ending December 31, 1910 | 1,666,223 | 609,956 | 2,568,201 | 30.75 |
| Year ending December 31, 1911 | 1,603,478 | 628,521 | 2,647,896 | 33.02 |
| Year ending December 31, 1912 | (c)1,529,600 | 642,807 | 2,707,369 | 35.4 |
| | 14,426,036 | 5,713,461 | £22,378,783 | 34.83 |

(a) No details available.

The Giant mine made a profit of £111,800 for the year 1912. The diminishing ore reserves total 243,687 tons, assaying 8.2 dwt. Mining and developing cost $1.89; sorting, crushing, transporting, $0.20; milling, $0.91; general, $0.36; total, $3.36. Some encouragement has been met with in boring to recover the ore-body in the lower levels. The Lonely mine is now yielding about £13,000 per month from 4000 tons. The mill will be increased by 5 stamps to treat 5000 tons per month.

The yearly report of the Eldorado mine shows that a profit of £116,691 was made in 1911–1912. The ore reserves are 150,000 tons, valued at 13 to 15 dwt. over a stoping width. These show a reduction of 50,000 tons, due to a shortening of the oreshoot because of disturbed ground on the eighth and ninth levels. The output of silver in Rhodesia in 1911 was 187,640 oz., derived from the gold ores.

*Russia* (By C. W. Purington).—According to the St. Petersburg "*Gold and Platinum*," the amount of gold dust and bullion delivered to the eight government assay offices at Bodaibo, Irkutsk, Nikolaievsk, Blagoveschensk, Zeisky, Pristan, Krasnoyarsk, Tomsk, and Ekaterinburg, and representing the bulk of the product for the mines of the Russian Empire for 1912, was 2232.5 poods, or 1,175,660 oz. crude. At an average value of $18 per ounce, this gold was worth $21,161,880, and was a decrease of $1,443,000 from the recorded statistics of 1911.

The product may be summarized as follows:

DISTRIBUTION OF RUSSIAN GOLD YIELD IN 1912.
(Crude gold, worth $18 per ounce.)

| Received at Assay Office at— | Poods. | Oz. |
|---|---|---|
| Blagoveschensk | 258.25 | 135,994.45 |
| Bodaibo | 678.50 | 357,298.10 |
| Irkutsk | 416.50 | 219,328.90 |
| Zeya | 365.30 | 192,366.98 |
| Krasnoyarsk | 59.30 | 31,227.38 |
| Nikolsievsk | 132.50 | 69,774.50 |
| Tomsk | 131.20 | 69,089.92 |
| Ekaterinburg | 191.00 | 100,580.06 |
| Total | 2232.55 | 1,175,660.29 |

To this estimate must be added, to get the total gold product of the Empire, a sum of $7,691,001, the totals, as given in *"Gold and Platinum,"* being 55,486,310 roubles, or $28,852,881, equivalent to 1,395,882 oz. fine gold.

This excess of gold produced, but not passing through the government treasury, is hard to account for. For the last 10 years the law has permitted the free exit of gold by any channel. As an assay charge of only 1 per cent. is made, however, most operators prefer to sell to the nearest government office. "Gold-books" are kept at all the mines, and the data recorded are eventually assembled in the government statistics. It is impossible to get the data from these until late in the succeeding year; consequently the figure given above can be only approximately correct. Gold sent by the copper mining companies either to St. Petersburg or out of the Empire in the form of gold slimes (Kyshtim alone accounting for 30,226 fine oz. gold and 248,875 oz. silver), probably accounts for about $1,000,000 annually, and it must be assumed that the remaining sum, over $6,000,000, is sent to China, or is taken back to Chinese ports by returning coolies.

Considering the remarkable falling off in production of the largest Siberian enterprise, the Lena Goldfields, Ltd., during 1912, the product of the Empire kept up surprisingly well. This is the more noteworthy since no new enterprises of any importance were started, and no new fields were discovered.

Lena District.—The Lena Company in 1912 produced only 272,252 oz. crude, as against 449,716 oz. in 1911, a decrease of 40 per cent. A strike resulting in great loss of human life, which occurred in the spring of 1912, was responsible for nearly half of the men quitting the country, and a complete reorganization of the management. Leon Perret, formerly manager of the Shuvalof Estate, has now been placed in charge of operations, and an increase of production this and next year is hoped for. The high working cost characteristic of the past will unquestionably be reduced.

In the Vitim and Olekma districts, surrounding the territory controlled by the Lena Goldfields, a considerable amount of exploration is now in progress. Some 1200 miles of river valleys, including the Bolshoi and Mali Patom, Chara, Cholonchon, Anangra, Vacha, Jouya, Dadychta, Mama and Makushina rivers and their tributaries are under examination by foreign engineers. Half a dozen Keystone drills are in use and numerous hand drills. The Olekma-Vitim Company, consisting of Dutch and English capitalists, has already during the past two seasons drilled enough ground to warrant the installation of one 7-ft. open-connected bucket dredge on the River Jouya, which is now being erected. Drilling is still going on. The company has acquired property in the best part of the Lena district, the properties having been negotiated by F. M. Nemshinoff, one of the most successful of the Lena miners. The vastness of the Olekma, Vitim and Lena fields may be realized when it is said that Nemshinoff's original holdings comprised over 500 miles of river and creek valleys, and he, although the principal, is only one of the several large proprietors in the region.

The Olekminsk Company, otherwise known as the Kalinin Company, has also large holdings on the Chara, Jouya, and Big Patom rivers. A portion of these claims on the Chara have been under examination by Russian engineers for nearly 2 years, and two dredges have been ordered. These also are understood to be of the 7-ft. open-connected type.

The Olekminsk Company has given an option on a portion of its ground to two subordinate syndicates, known respectively as the Kizina and Murukan, in which some of the largest companies in London are represented, as also some American capital. Drilling is now being done on the claims under the direction of W. E. Thorne. It is also understood that a syndicate is being formed, composed of Prince P. Wolkonsky and Russian capitalists for taking an option on some 24,000 acres on the Anangra, Dodychta, Molvo and Chara rivers from the Olekma-Vitim Company. Drilling will be commenced as soon as practicable under the direction of American engineers. The Dodychta, which is a recent discovery in the district, is promising for hydraulicking, as the streams head in high mountains, and have heavy grades.

Amur District.—Although the product from this district has shown no remarkable increase, the progress of the two dredges on the Kolchan property is of special interest. It will be remembered that this property was equipped with an 8-ft. dredge, of California type, in 1910-11, and with a stacker scow plant. The dredge in 1912 treated 382,550 cu. yd. of gravel, recovering 32 cents per cubic yard at an operating cost of 6.5 cents, exclusive of royalty, administration and winter up-keep.

The stacker scow treating a sticky clay gravel treated 68,685 cu. yd., recovering 82.5 cents per cubic yard at a cost of 26.5 cents. The total results of the two plants were 451,235 cu. yd. treated recovering a total of $180,880 with $137,565 gross profit, being a recovery of 40 cents, at a working cost of 9.6 cents per cubic yard.

The stacker scow has now been changed into a 3-ft. continuous bucket dredge, it having been originally designed with this intention. Enough ground has been prospected to give the property, with both dredges, a life of 10 years, and everything appears to indicate this, the only American dredge installation in Siberia, will be a profitable enterprise. Great credit is due to the designers and constructors of the 8-ft. dredge, as well as to all concerned in the enterprise, as it represented a pioneer installation in a wild country under extremely difficult conditions. It is understood that both dredges have now (May 26, 1913) started operations and it is confidently expected that the entire cost, including all administration and winter up-keep charges, will not exceed 15 cents per cubic yard for 1913.

No new properties have so far been opened up in the lower Amur field, but much of this and the entire upper Amur territory remain a virgin territory for dredge exploration.

In the upper Amur district, on the tributaries of the Zeya river, the Verkny-Amur Company has initiated hydraulic mining on a small scale. Ten miles of ditch have been constructed, probably the longest ditch yet built in Siberia for hydraulic mining. Up to the present very little is known about the installation or what success has attended it. It seems probable that hydraulic conditions exist, however, as there are extensive benches of gravel in the district, and conditions for bringing water under pressure and for providing dump room are said to be good.

Trans-Baikal and Mongolia.—At the government mines on the Unda river, Trans-Baikal district, installations of a novel character are contemplated. American engineers are endeavoring to solve the problem of working extensive benches of gravel, which are known to carry pay values, and lie in a position affording ample dump room for tailings. The thickness is about 30 ft. The gravel is frozen, and there is no possibility of obtaining sufficient water under pressure for hydraulicking. A modification of the Australian type of barge sluicing plant, using forced hydraulicking and either centrifugal pump or bucket elevator, is proposed. The gravel is a medium coarse, clean rounded wash, and the duty of the miner's inch on the frozen material would probably be high, if the piping were properly directed.

The Tushetukan and Tsentsenkan Aimak Mining Company of Mongolia, otherwise known as "Mongolor," the Russian company oper-

along north of Taga along the Kansan frontier produced 21,130 oz. crude of alluvial gold worth $360,341. It is understood that this company has recently acquired also a large dredging property on the River Kruchina near China, Far Siberia.

Yenisei District.—The three dredging companies operating in what is known as "The Northern Taiga" Forest, which lies north of the River Angara some 200 miles down the main river Yenisei from the City of Krasnoyarsk, have continued to contribute their feeble quota to the gold production of Siberia. It appears that ten or twelve small dredges operating in this field are recovering values of from 15 to 30 cents per cubic yard and that the operations are profitable. The indications are that the field is a promising one for an installation of large type machinery, but up to the present no such installations have been contemplated by owners.

The "Druga Company," a Russian concern and the most successful of the three, publishes a detailed balance sheet in which some very interesting items of cost are given. Unfortunately this balance sheet is not available for publication at present.

In the other gold fields of Siberia no developments of any note are to be recorded. New gold discoveries are said to have been made at various points along the West Mongolian border, especially in the region of Lake Zaisan, and an extensive drilling campaign is contemplated to test the value of stream gravels there.

An increasing gold production may be looked for from the Ural, both on account of the improvements in copper smelting and consequent recovering of accompanying gold values; and also as a result of the gradual increase of the gold-dredging industry.

*Salvador.*—The Butters Salvador mine, at Santa Rosa and Divisidero mine, at La Union, were the chief producers of 1912. The output of the Salvador property continued at about $60,000 to $65,000 per month, with the Divisidero production at about $40,000 per month. The cyanide process is now in use at both plants. The ore reserves at the Butters properties are reported to be encouraging. The exports from Salvador during 1911 were as follows: Gold in bars, $760,413; gold and silver amalgams, concentrates, etc., $700,256; silver in bars, $160,702.

Transvaal (By H. F. Marriott).—The year 1912 provided a new high record in the production of gold from the Witwatersrand area, the increase over 1911 amounting to no less than £4,700,000, while the tonnage crushed showed an increase of approximately 1,600,000. It is extremely gratifying to observe that the downward tendency of yield from which has been in operation ever since the war (1899-1902) has received a check, the yield per ton amounting to 29.4s., an advance

of 1.3s. on the 1911 figure. This yield is, in fact, better than that of any year since 1908.

The general tendency to meet the increasing scale of underground operations is toward the installation of comprehensive schemes of mechanical transport underground to connect the various sections of each mine by one main artery with the principal loading station at each main shaft. This insures fuller efficiency of the hoisting arrangements and does away with the congestion of traffic in the immediate locality of the more active operations. Greater attention was paid in 1912 toward mining to a clear profit and this was reflected in a higher yield and consequent higher profit from those mines in which the policy was actively adopted.

No new producers came into the list during the year and the increased tonnage and yield are therefore all the more noteworthy. The duty per stamp again showed a marked increase, from 7.8 tons per day in 1911 to 8.5 tons per day at the close of 1912. In 2 years the average increase has amounted to about 20 per cent. This, of course, does not indicate the progress made in crushing duty in new plants as compared with old ones, as the figures quoted include all the plants at work.

The year saw the passing of the Salisbury mine, one of the earliest producers on the fields, which commenced operations in 1887. Although the total area of this mine amounted only to about 20 claims, it has produced profits sufficient to pay dividends totaling £248,823.

Considerable disappointment was experienced during the year by the failure of the new plant at the Benoni mine to come up to expectations. The cyanide portion of this plant was in some respects rather in the nature of an experiment, sands and slimes being treated together by a continuous process, and it was this portion of the plant which failed to fulfill the estimate made of its capabilities. It is stated that the screw elevators failed to transfer satisfactorily the settled pulp in the dewatering cones, thus necessitating an alternative scheme being put in operation, the delivery of a different class of product and the consequent disorganization of the remainder of the scheme of treatment. Extensive alterations and additions were recommended, but the company was not in a position to meet the extra cost involved, and the plant was shut down after running 7 months.

Four Nissen stamps after a year's trial have been accepted as a regular part of the City Deep stamp-mill equipment. These stamps are stated to require 30 per cent. less power than the original City Deep stamps for the same tonnage crushed. The Giesecke ball mill, of which a trial was made in 1911, did not prove a success and was not adopted on these fields. The Merrill zinc-dust process has proved a pronounced success in certain

reduction plants where the slime solutions are comparatively strong, but in cases where the solutions are very dilute the process has not shown any advantage over zinc shavings.

The filling of worked-out stopes with sands, which was inaugurated in 1910, was continued with vigor at many of the mines, with beneficial effects upon the stability of shafts and workings. The Ferreira Deep in particular may be quoted to indicate the progress made. Up to the end of September, 750,000 tons had been sent down this mine at a cost of about 1s. 3d. per ton. The usual practice is to run the sand down the mine mixed with water, but at the Cinderella Consolidated, where the great length of vertical pipe in the shaft resulted in excessive wear and tear of the pipes, a method was installed of dropping dry sand through a vertical wooden-box launder, and commencing the water-borne system at the foot of the shaft. It is stated that, with the moderate amount of filling in this mine, the new method is meeting with success.

An attempt was recently made to revive the old controversy as to the decadence of value of the reefs on the Rand with depth. As if to confound the adherents to this theory, almost simultaneously the news arrived that in the 19th level of the Village Deep, the main reef leader had been cut and had returned an average assay of 54s. over 39 in., a figure well above the average of the mine above. This level is the lowest point reached in the mine, the vertical depth being about 4100 ft., and the lateral distance from the outcrop about 7000 ft.

YEARLY PRODUCTION OF TRANSVAAL MINES.
(Chamber of Mines Returns.)

| Year. | Witwatersrand District. | | | Outside Mines Value. | Transvaal Total. |
|---|---|---|---|---|---|
| | Tons Milled. | Value. | Value per Ton Milled. Shillings. | | |
| 1890 | 730,000 | £1,735,491 | 47.4 | £134,154 | £1,869,645 |
| 1891 | 1,154,144 | 2,556,328 | 44.2 | 367,977 | 2,924,305 |
| 1892 | 1,979,354 | 4,297,610 | 43.4 | 243,461 | 4,541,071 |
| 1893 | 2,203,704 | 5,187,206 | 47.0 | 293,292 | 5,480,498 |
| 1894 | 2,830,885 | 6,963,100 | 49.2 | 704,052 | 7,667,152 |
| 1895 | 3,456,575 | 7,840,770 | 45.2 | 728,776 | 8,569,555 |
| 1896 | 4,011,697 | 7,864,341 | 39.2 | 739,480 | 8,603,821 |
| 1897 | 5,325,355 | 10,583,616 | 39.74 | 1,070,109 | 11,653,725 |
| 1898 | 7,331,446 | 15,141,376 | 41.3 | 1,099,254 | 16,240,630 |
| 1899 | 6,872,750 | 15,067,473 | 48.84 | 661,220 | 15,728,693 |
| 1900 | 459,018 | 1,510,131 | 65.82 | ..... | 1,510,131 |
| 1901 | 412,006 | 1,014,687 | 49.25 | 81,364 | 1,096,051 |
| 1902 | 3,416,813 | 7,179,074 | 42.00 | 74,591 | 7,253,665 |
| 1903 | 6,105,016 | 12,146,307 | 39.79 | 442,941 | 12,589,248 |
| 1904 | 8,058,295 | 15,539,219 | 38.46 | 515,590 | 16,054,809 |
| 1905 | 11,160,422 | 19,991,658 | 35.82 | 810,416 | 20,802,074 |
| 1906 | 13,571,554 | 23,615,400 | 34.8 | 964,587 | 24,579,987 |
| 1907 | 15,523,299 | 26,421,837 | 34.04 | 981,901 | 27,403,738 |
| 1908 | 18,196,589 | 28,810,393 | 31.6 | 1,147,217 | 29,957,610 |
| 1909 | 20,543,759 | 29,900,359 | 29.1 | 1,025,429 | 30,925,788 |
| 1910 | 21,432,541 | 30,703,912 | 28.5 | 1,297,823 | 32,001,735 |
| 1911 | 23,888,258 | 33,543,479 | 28.1 | 1,498,006 | 34,041,485 |
| 1912 | 25,486,361 | 37,182,795 | 29.0 | 1,574,765 | 38,757,560 |

RETURNS FROM TRANSVAAL ORES.

| Year. | Recovery Per Ton | Costs per Ton. | Dividend per Ton. | Year. | Recovery per Ton. | Costs per Ton. | Dividend per Ton. |
|---|---|---|---|---|---|---|---|
| | s. | s | s. | | s. | s. | s. |
| 1903*..... | 39.8 | 28.8 | 11.0 | 1908..... | 31.6 | 22.2 | 9.4 |
| 1904..... | 38.5 | 29.0 | 9.5 | 1909..... | 29.1 | 20.0 | 9.1 |
| 1905..... | 35.8 | 27.2 | 8.5 | 1910..... | 28.5 | 18.4 | 8.52 |
| 1906..... | 34.8 | 26.4 | 8.2 | 1911..... | 28.1 | 18.1 | 6.74 |
| 1907..... | 34.0 | 25.0 | 9.0 | 1912..... | 29.3 | 18.9 | 6.54 |

* 1900-1902 War period.

Perhaps the most noteworthy general feature of 1912 was the development of the far-eastern section of the Rand. Up to a few years ago this area, with the exception of one or two established mines, was looked upon with some disfavor as being highly speculative and much poorer than the main portion of the Witwatersrand. It has now become alive with expansion and progress.

The New Modderfontein has developed into one of the foremost mines of the Rand, with a declared monthly profit of nearly £50,000, and a reserve of developed ore amounting to 4,000,000 tons, containing gold to the amount of 34s. per ton. The Brakpan, which commenced crushing in May, 1911, is now declaring profits of over £40,000 per month, with an average profit per ton crushed of about 14s. 3d. The Modderfontein B commenced crushing operations in November, 1911, and the profit declarations are about £30,000 per month, a return considerably in excess of all early estimates of the value of the mine. The Geduld has not gone ahead so fast, but from a monthly average of £2900 during 1911, it increased its profits to nearly £5000 per month. These four companies in 1912 produced a gross profit of approximately £1,400,000 from a tonnage milled of about 1,730,000, or an average of 16s. per ton.

The efforts which the various groups have been making for some time past to abolish the evil of indiscriminate competition in the recruitment of native labor has resulted in the formation of a new organization, to control the recruiting on coöperative lines of all the mining groups on the Rand, with one exception. This organization has not yet been sufficiently long in existence to show what effect it will have upon the labor supply and its cost.

The number of natives in employment in 1912 was slightly in excess of the previous year; the highest point was reached in April when 215,000 were in the service of Transvaal gold mines. The number of whites employed has varied little during the last 3 years.

LABOR EMPLOYED IN TRANSVAAL GOLD MINES
(Mines Department Statistics.)

| | | White. | Colored. | Chinese. | Total Colored and Chinese. | Death Rate per 1000 Native Miners. |
|---|---|---|---|---|---|---|
| 1902 | July | 8,162 | 32,616 | ..... | 32,616 | ..... |
| | Dec. | 10,292 | 45,698 | ..... | 45,698 | ..... |
| 1903 | June | 11,815 | 66,221 | ..... | 66,221 | 80.93 |
| | Dec. | 12,695 | 73,558 | ..... | 73,558 | ..... |
| 1904 | June | 13,413 | 74,632 | 1,004 | 75,636 | 48.29 |
| | Dec. | 15,023 | 83,639 | 20,885 | 104,524 | ..... |
| 1905 | June | 16,939 | 104,902 | 41,340 | 146,242 | 51.11 |
| | Dec. | 18,159 | 93,831 | 47,267 | 141,098 | ..... |
| 1906 | June | 17,959 | 90,882 | 52,352 | 143,234 | 38.54 |
| | Dec. | 17,495 | 98,156 | 52,917 | 151,073 | ..... |
| 1907 | June | 17,166 | 111,862 | 51,517 | 163,379 | 36.75 |
| | Dec. | 17,697 | 129,618 | 37,118 | 166,736 | ..... |
| 1908 | June | 18,181 | 147,557 | 21,460 | 169,017 | 35.81 |
| | Dec. | 19,005 | 164,826 | 12,275 | 177,101 | ..... |
| 1909 | June | 21,620 | 175,895 | 6,317 | 183,212 | 37.72 |
| | Dec. | 23,077 | 168,665 | 2,038 | 170,703 | ..... |
| 1910 | June | 24,794 | 201,770 | ..... | 201,770 | 35.72 |
| | Dec. | 25,376 | 191,784 | ..... | 191,784 | ..... |
| 1911 | June | 25,960 | 106,197 | ..... | 206,197 | 31.01 |
| | Dec. | 25,108 | 194,286 | ..... | 194,286 | ..... |
| 1912 | June | 24,885 | 208,537 | ..... | 208,537 | 28.63 |
| | Sept. | 24,221 | 195,993 | ..... | 195,993 | ..... |

At the Randfontein Central, during 1912, 752 stamps, out of a total of 1000 erected, crushed 2,573,908 tons for a yield of 23s. 11.7d. per ton, at a cost of 17s. per ton milled. Gross profit amount to £886,399. The development work for the year was 81,445 ft., with 321,771 cu. ft. of excavation for sumps and stations. The ore reserves amount to 7,600,000 mill tons, assaying 6.2 dwt. Of this, 6,350,781 tons are valued at 28s. 10d. per ton, and the remainder is at present unpayable, valued at 13s. 7d. per ton. During 1913 it is hoped to drop all stamps and increase tonnage milled to 3,100,000 tons.

The New Modderfontein during the fiscal year 1911–12 milled 585,500 tons, valued at 34s. 6d. at a working cost of 18s. 8d. for a working profit of 15s. 10d. per ton, or a total of £478,862; £350,000 was declared in dividends. The total ore reserves and pillars total 4,067,000 tons, assaying 8 dwt., with 723,000 tons of estimated 3 to 4 dwt. content. The famous circular shaft was sunk 1167 ft. during the year on an average rate of under 100 ft. per month. The average stope width was 57 in. Mining costs were: Stoping, 3s. 7d.; timbering and rock walling, 7d.; shoveling and tramming, 3s. 4d.; pumping, winding, etc., 2s. 8d.; development, 1s. 5d.; total, 11s. 7d. per ton. Cyanide pulp assayed 8s. 11d. per ton and residues 9d. per ton.

The Simmer & Jack mine during the year ended July 31, 1912, made a working profit of £529,944. The 320 stamps and seven tubes milled 863,500 tons of the 922,624 tons mined; 528,828 tons came from stopes and 393,796 tons from foot and hanging wall and pillars in old workings.

Costs were: Mining, 7s. 0.794d.; development, 3.438d.; surface transport, sorting and crushing, 4.852d.; stamp milling, 11.414d.; tube milling, 7.422d.; sand treatment, 11.712d.; slime treatment, 5.796d.; general, 1s. 0.158d.; maintenance, 0.576d.; total, 11s. 10d. per ton.

*West Africa.*—The output of gold is reported by the West African Chamber of Mines at 362,940 oz. in 1912, compared with 261,784 oz. in 1911 and 189,443 oz. in 1910. Estimating the fineness of the bullion by comparison with preceding years, the value of the 1912 output was £1,451,760, the largest annual amount yet produced.

GOLD PRODUCTION OF GOLD COAST COLONY AND ASHANTI, SINCE 1882.

| Year. | £ | Year. | £ | Year. | £ | Year. | £ | Year. | £ |
|---|---|---|---|---|---|---|---|---|---|
| 1882..... | 61,188 | 1889... | 103,200 | 1896.. | 86,186 | 1903... | 254,790 | 1910... | 755,985 |
| 1883..... | 52,435 | 1890... | 91,657 | 1897.. | 84,797 | 1904... | 345,608 | 1911... | 1,069,442 |
| 1884..... | 66,188 | 1891... | 88,112 | 1898.. | 63,837 | 1905... | 657,330 | 1912... | 1,451,760 |
| 1885..... | 89,981 | 1892... | 98,805 | 1899.. | 51,299 | 1906... | 877,568 | ..... | ..... |
| 1886..... | 74,878 | 1893... | 79,099 | 1900.. | 38,006 | 1907... | 1,154,885 | ..... | ..... |
| 1887..... | 81,168 | 1894... | 76,795 | 1901.. | 22,186 | 1908... | 1,182,680 | ..... | ..... |
| 1888..... | 86,510 | 1895... | 91,497 | 1902.. | 96,880 | 1909... | 955,635 | ..... | ..... |

In 1912, the production was supplied by eight mining and three dredging companies. The chief contributors in 1911 were: Ashanti Goldfields, 114,988 oz.; Prestea Block A, 37,424 oz.; Abosso, 33,749 oz.; Bibliani, 22,394 oz.; Taquah Mining & Exploration, 11,727 oz.; three dredging concerns, 15,772 oz., worth 80s. per oz., a total of £63,088 for that branch of the industry. Railway rates in the district are abnormally high, though this disadvantage is partly offset by the superior class of native labor obtainable.

During 1912 the Ashanti Goldfields produced at the rate of £40,000 per month, at which rate, its reserves at the end of the year were estimated to be good for 2 1/2 years. The Abosso mine has succeeded in reducing its mining costs, and the Prestea is enlarging its output.

In the year ended June 30, 1912, the Taquah Company, operating 20 and then 30 stamps, treated 43,041 tons of ore and recovered 29,804 oz. gold; at the same time, 10,069 tons of slimes carrying 2 dwt. per ton were stored awaiting the completion of a plant for treating them. Reserves at the end of the year were estimated at 168,551 tons, averaging 62s. 3d. The mine is developed to the twelfth level. At the Abosso, which is now subsidiary to the Taquah Company, during the same fiscal year, 89,322 tons were treated, with a recovery of 36s. 10d. per ton. Reserves on June 30, 1912, were estimated at 229,128 tons, averaging 40s. 6d., an increase of 69,000 tons during the year.

# Progress in Gold and Silver Milling During 1912.

By Charles H. Fulton

## Introduction

This article takes the place of that on "Progress in Cyanidation" in previous volumes of the Mineral Industry. It includes all gold and silver milling operations but gives no detailed description of crushing, classifying or concentrating machinery and related apparatus or of amalgamating devices which are discussed in Professors Richards' and Locke's "Progress in Ore Dressing."

The year 1912 marks a steady progress in the art of gold and silver milling and a number of innovations have been introduced, notably the cyanide-amalgamation practice at the Nipissing high-grade mill and the introduction of aluminium as a precipitant for silver at the Nipissing low-grade mill at Cobalt. A description of this last innovation is not included in this article as detailed data was not available at the time of writing.

The decision in the filter suits in favor of the Moore Company will probably tend to clarify and settle the turbid slime question. The filter decision caused a renewal of the discussion on continuous decantation and the possibility of doing without filters. The vacuum filter marks such a great advance in slime treatment that it is safe to say, that it has come to stay, and that its use will unquestionably increase rather than decrease.

The most interesting paper of the year is that of A. J. Clark and W. J. Sharwood on the "Homestake Milling Practice." This paper is worthy of the notice of all engaged in gold and silver milling, for it describes practice that in part at least may be profitably imitated at many mines. One feature of cyanidation, namely, the smelting of precipitate seems to be in need of improvement and present practice at most mills is very crude and cumbersome. It is worthy of note that the question is receiving attention and that improvement may be looked for.

## Milling Practice

**United States.**—The Mexican Mill at Virginia City, Nevada, is described by Whitman Symmes.[1] It treats from 70 to 90 tons of ore per day from the Mexican Mine on the Comstock Lode. The ore which varies considerably in composition and precious-metal content consists of quartz, clay, diorite and diabase wall rock and a small amount of sulphide minerals. Two-thirds of the ore value is in free gold and one-third in silver, as argentite. The analysis of average ore is $SiO_2$, 80.56; Pb, 1.57;

[1] *Eng. and Min. Journ.*, XCIV, 701.

Zn, 1.60; Cu, 0.78; S, 2.17; $Al_2O_3$, 5.92; $Fe_2O_3$, 3.78; CaO, 1.05; MgO, 2.21 per cent.; gold and silver, $15 to $40 per ton. The ore is crushed by a No. 3 McCully crusher at the Union Shaft and conveyed by belt conveyors to the mill bin. At the mill, crushing is done by ten 1250-lb. stamps, in cyanide solution, through 4-mesh screens. The pulp passes directly, without classification to a 6-ft. Trent Chilean Mill, crushing through "ton cap" 24-mesh screens (aperture = 0.018 in.) and thence to a duplex Dorr Classifier, the sands from which are ground in a 5×18-ft. tube mill and returned to the classifier by a bucket elevator. The slime (84 to 91 per cent. through a 200-mesh screen) from the classifier (8 solution to 1 ore) go to a 14×24-ft. Dorr thickener No. 1, which discharges pulp (2 solution to 1 ore) to a 14×24-ft. Trent agitator No. 1 and overflow solution to three clarifying presses, from which the clear solution goes to a special method of zinc-dust precipitation. This is the only solution which is precipitated. Pulp from No. 1 agitator flows continuously to Dorr thickener No. 2, which is fed also with barren solution. The overflow solution is returned to the mill solution storage tanks, while the thickened pulp flows to Trent agitator No. 2 and from thence to Dorr thickener No. 3, which also receives barren solution, and discharges its overflow to the mill storage. The pulp from this thickener passes to Trent agitator No. 3, and thence to an Oliver filter where the slimes are washed with both barren solution and water. It will be noted that the mill operates on a continuous system, and employs a form of continuous decantation and dilution in combination with an Oliver filter.[1] The Trent agitators give trouble by clogging at the nozzles, and they seem an unsuitable device in a continuous process. The weak point of the Oliver filter is its low efficiency in washing out valuable solution from the slime, but the continuous decantation and addition of barren solution preceding its application makes its use possible, where with richer solutions at the end of the slime treatment it would not be applicable. The tailings from the filter contain 8 to 10 cents per ton in dissolved gold and silver. The continuous decantation and addition of barren solution, however, is not applied to aid the Oliver filter but is an essential feature of the treatment method, for the ore contains an appreciable amount of sulphides, and the frequent addition of fresh solution is necessary to obtain extraction. Extensive tests on the ore previous to the erection of the mill indicated that fine grindings and direct cyanidation of all the ore gave a higher extraction than amalgamation followed by concentration for the removal of the sulphides, and a cyanidation of the tailings. The cyanide consumption at present is about 1.50 lb. per ton of ore. Solutions are heated to 96° C.

[1] See MINERAL INDUSTRY, XX, 339, 341, 343.

The West End Consolidated Mill[1] at Tonopah, Nevada, is described by J. P. Hart and H. L. Williams. This 20-stamp mill is a remodeled plant, being originally the old Midway Mill, built in 1902 as a pan amalgamation mill. It treats approximately 100 tons per day, of characteristic low-grade ore, $10 to $14 and under per ton. The mill is an all-sliming, non-concentrating plant, employing stamps, tube mills, Dorr classifiers and thickeners, Trent agitators, a 100-leaf Butters' filter, and zinc shaving precipitation. Precipitate is melted in a Faber du Faur furnace. It is found that on the Tonopah ores concentration may be omitted for the lower grade ores, but when the ore value reaches $14 to $18 per ton extraction falls off and solution difficulties appear, so that concentration as a step in the milling process becomes essential. The original paper gives interesting detail in reference to apparatus for the transfer of pulp and solutions. Four No. 3 Gould diaphragm pumps are used to transfer the pulp (2 solution to 1 solid) to the Trent agitators. These pumps which have variable stroke and speed are very satisfactory for the work. In connection with the Trent agitators, centrifugal pumps of local manufacture are used. In these the bearings are separate babbitted cast-iron cylinders that can be slipped into place in exact alignment in a few minutes. The thrust otf he runner is taken up by a pressed steel ball race running in oil on the end bearing. A nut and lock-nut beyond the ball race allows the runner to be slacked off to the suction to maintain efficiency. The runner is of the open-vane type and runs in a hard cast-iron liner within the shell, the liner being fitted with ground joint to prevent leakage. The vacuum pump for the Butters' filter is of the Connersville cycloidal type. This pump maintains a maximum vacuum of 19 in. at 3 to 4 h.p. The net cost of the pump was $175.

The Nevada Hills Mill[2] at Fairview, Nevada, described last year[3] is briefly discussed by W. A. Scott. The mill of the Associated Manhattan Milling Co., at Manhattan, Nevada, is described by J. C. Kennedy.[4] This is a custom mill treating 50 to 60 tons of ore per day, the main value of which is in gold. The ore is rough crushed in a Forster crusher and then after mechanical sampling passes to ten 1050-lb. stamps, crushing in 1.5 lb. KCN solution. The sands from the Akins' classifier are ground in a 4.5×16 ft. tube mill lined with the Komata liner. The overflow (65 to 70 per cent. through a 200-mesh screen) from the classifier goes to a 10×20 ft. Dorr thickener, the clear solution overflow from which passes to zinc shaving precipitation. The thickened pulp goes to a 20×16 ft. Trent agitators, where the solution is raised to 2 lb

and *Min. Journ.*, XCIV, 163.
and *Sci. Press*, CIV, 143.
RAL INDUSTRY, XX, 373.
and *Sci. Press*, CV, 108.

KCN per ton, agitation being carried on for 16 to 24 hours. From the agitators the pulp passes to an 18×26 ft. storage tank and thence to a 45-leaf Butters' filter. The solution from the filter is precipitated by zinc shavings. In the precipitation boxes the two head compartments are filled with excelsior to clarify the solution. The Ophir cyanide plant[1] near Virginia City, Nevada is described by Walter Techow. The mill treats about 100 tons of tailings of a value of about $5 per ton, extracting 80 per cent. at a cost of $1.25 per ton. The grinding is done in a 5×22 ft. tube mill in cyanide solution. Further treatment is carried out by means of Dorr thickeners, Trent agitators, Butters' filter and zinc shaving precipitation. The consumption of cyanide is about 0.75 lb. per ton which is remarkably low for the treatment of tailings. M. W. von Bernewitz[2] describes some details of practice of the mills at Tonopah, Nevada. These mills are the Belmont, Extension, MacNamara, Montana and West End at Tonopah, and the Belmont and Tonopah Mills at Miller's, 12 miles north. Crushing in all the mills is done in weak and warm solutions.

TABLE I.—PRACTICE AT TONOPAH.

| Name of Mill. | Type. | Concentration. | Kind of Agitator. | Precipitation. | Notes. |
|---|---|---|---|---|---|
| New Belmont | All slime | Yes | Pachuca | Zinc dust | Number of tube mills in district 16. Ranging from 5×18 to 5×22 ft. |
| Extension | All slime | Yes | | Zinc shavings. | |
| MacNamara | All slime | No | Trent | Zinc shavings. | |
| Montana | All slime | Yes | Hendryx Trent | Zinc dust. | |
| West End | All slime | Yes and no | Trent | Zinc shavings. | |
| Belmont | All slime | No | Ordinary mechanical. | Zinc shavings. | |
| Tonopah | Sand and slime. | Yes | Ordinary mechanical. | Zinc shavings. | |

The Goldfield Consolidated Mines Co.[3] at Goldfield, Nevada, is installing equipment to treat the residues from the concentrate treatment.[4] The concentrate will be roasted in two Edwards' duplex roasting furnaces, each with a 112×13 ft. hearth, cooled in a Baker cooler, reground in cyanide solution in a 5×18 ft. tube mill, and further treated in agitators and a filter in the usual manner. The cyanide plant of the Empire Mines at Grass Valley, California is described by F. A. Vestal,[5] The flow-sheet is shown in Fig. 1. A noteworthy feature of the mill is the continuous treatment of the slime and the treatment of the concentrate which is ground in a tube mill and then passed over plates and mixed with the sand for cyanidation. The gold precipitate from the Merrill presses is melted direct without drying, in a Harvey tilting oil-fired fur-

[1] *Min. and Sci. Press*, CV, 703.
[2] *Min. and Sci. Press*, CV, 828.
[3] *Min. and Sci. Press*, CIV, 198; *Eng. and Min. Journ.*, XCIII, 318.
[4] MINERAL INDUSTRY, XX, 350.
[5] *Min. and Sci. Press*, CV, 586, and *Mines and Minerals*, XXXII, 113.

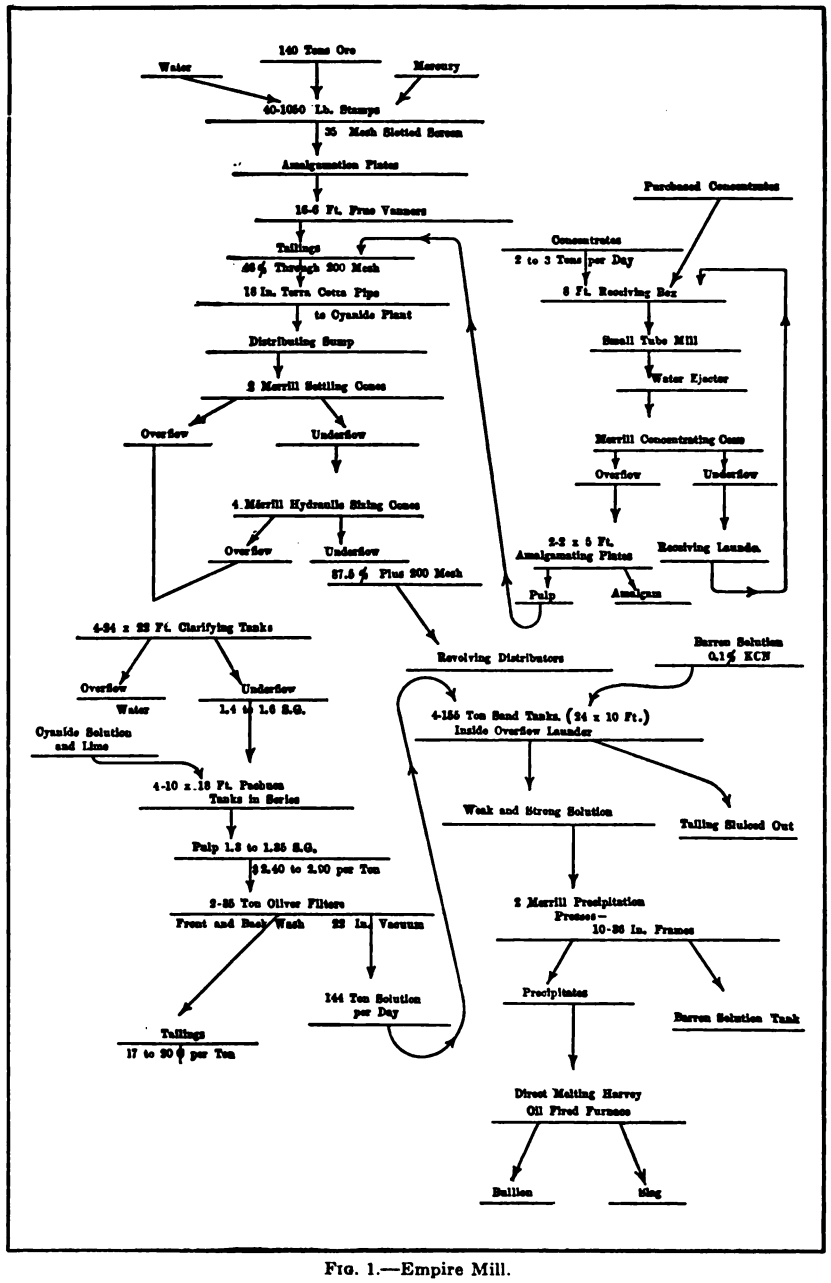


FIG. 1.—Empire Mill.

nace with the following flux: 50 per cent. borax, 20 per cent. soda, 2 per cent. silica, referred to the weight of precipitate. The slag is rich and is usually shipped to a smelter, but experiments are now being made by grinding it in a pan with mercury with promising results. An extraction of 87 to 89 per cent. is obtained on sand and 90 to 93 per cent. on slime.

The Black Oak Mill at Soulsbyville, Tuolumne County, Calif., is described by C. H. Urquhart.[1] This mill treats about 100 tons of $20 hard siliceous gold ore. It marks a departure in the treatment of Mother Lode ores, in that it cyanides the ore as all slime and does not employ concentration or amalgamation. The ore is crushed by twenty 1250-lb. stamps in 0.187 per cent. cyanide solution through 10-mesh screens. The pulp passes to a Dorr duplex classifier the underflow from which is crushed in a 5×18 ft. tube mill, enough solution being added to the tube mill feed to bring the moisture content to 39 per cent. The tube mill product is returned to the classifier by a bucket elevator. The overflow from the classifier (6 solution to 1 solid) passes to a 20×10 ft. Dorr thickener, from which the pulp (2 solution to 1 solid) is pumped by a 2.5 in. air lift to three 10×30 ft. Pachuca agitators in series for continuous agitation. The pulp from the agitators and from the first Dorr thickener flows to a second 20×10 ft. Dorr thickener, to which is further added barren solution from the stock tanks in order to bring down the gold contents of the solution before the thickened pulp is sent to the Oliver filter. The decanted solution from the second thickener passes to a collecting tank, which also receives the solution from the vacuum pump of the Oliver filter. This solution is then passed through one of two 36–24 in. frame Shriver filter presses for clarification and thence to gold solution tanks from which it goes to a 16–52 in. frame Merrill press, zinc dust being added as usual at the suction of the pump feeding the press. Lime is added to the ore at the batteries and to the pulp at the agitators. The Oliver filter requires a vacuum pump of higher efficiency and greater capacity than other vacuum filters. The pump used at this mill is a modified type of that designed by G. D. Kislingbury for the Oliver filter. It is described in some detail. Commercial litharge is used in the solution in place of lead acetate to precipitate soluble sulphides, being considerably cheaper. The gold-zinc precipitate is smelted direct but the bullion produced is base (850 fine) and a change is contemplated.

A. Del Mar[2] briefly describes the battery foundations and the construction of the Bishop Creek Mill, 18 miles from Bishop, Inyo County, Calif. Philip Argal[3] gives the history of cyaniding the low-grade telluride ores of Cripple Creek. The new Victor mill of the Portland Gold

[1] *Min. and Sci. Press*, CV, 687.
[2] *Min. and Sci. Press*, CV, 561.
[3] *Min. and Eng. World*, XXXVI, 915.

Mining Company[1] treats the low-grade sulpho-telluride ores normally extracted during mining operations for the higher-grade ores, and from new development work. The ore is crushed in Blake crushers and rolls, and then passes to four–6 ft. Chilean mills crushing in cyanide solution through 20-mesh screens. The pulp is then concentrated, the tailings separated into sand and slime and the sand concentrated again. The sand is leached and slime treated by agitation and filtration. Concentrate is shipped to Colorado City, where it was treated by chlorination. Zinc dust precipitation is used. The mill treats from 8000 to 10,000 tons per month. In 1911 the average gross value of the ore was $3.51 per ton, and the extraction 81.4 per cent. The net profit from the milling operation was $128,738, which, of course, does not take into consideration the cost of mining. No detailed description of the mill is available as yet. The chlorination mill of the same company at Colorado City, has been converted into a cyanide plant. The ore is roasted, ground in cyanide solution in tube mills, and the tube mill product treated in Merrill presses. Zinc dust precipitation is used. This mill treats the higher-grade ores from the Portland mine.

W. R. Dodge[2] describes the retreatment of mill tailings at the Isabella Mill, Cripple Creek, more particularly the sampling of tailings dumps, the excavation of the material from the dump, and the filling of the leaching vats. The cost of retreating these tailings is given as 24.1 cents per ton.

Stratton's Independence Mill[3] for the year ending June 30, 1912, treated 112,392 tons of ore, value $3.10 per ton at a cost of $1.27 per ton. The extraction was 73.63 per cent.; 42.19 per cent. by concentration and 31.44 per cent. by cyanidation. The Colburn-Ajax mill at Victor, Colo., is described in reference to mechanical details by S. A. Worcester.[4] The essentials of treatment employed in this mill, which uses the Clancy process, have been described.[5] The article describes a zinc dust feeder with some new features. The electrolizing equipment has been changed. Formerly fused magnetite anodes were used; these are now replaced by Acheson graphite rods, 40 in. long and 4 in. diameter. The cathodes are curved iron plates 40×6×0.125 in., soldered to a 10-in. diam. spider, and surround the anode. These electrolizing baskets are immersed in the pulp in the agitators. It is stated[6] that the plant is working successfully and recovers 80 per cent. from $4 ore at a cost of about $1. No official report of results has however been published. The Tomboy Mill[7] is

[1] *... and Minerals*, XXXII, 562; *Met. and Chem. Eng.*, X, 127.
[2] *... and Eng. World*, XXXVI, 410.
[3] *... Min. Journ.*, XCIV, 939.
[4] *... Min. Journ.*, XCIII, 753.
[5] ... INDUSTRY, XX, 326, and previous volumes.
[6] *... Sci. Press*, CIV, 168, and *Mines and Minerals*, XXXII, 748.
[7] *... Sci. Press*, CV, 820.

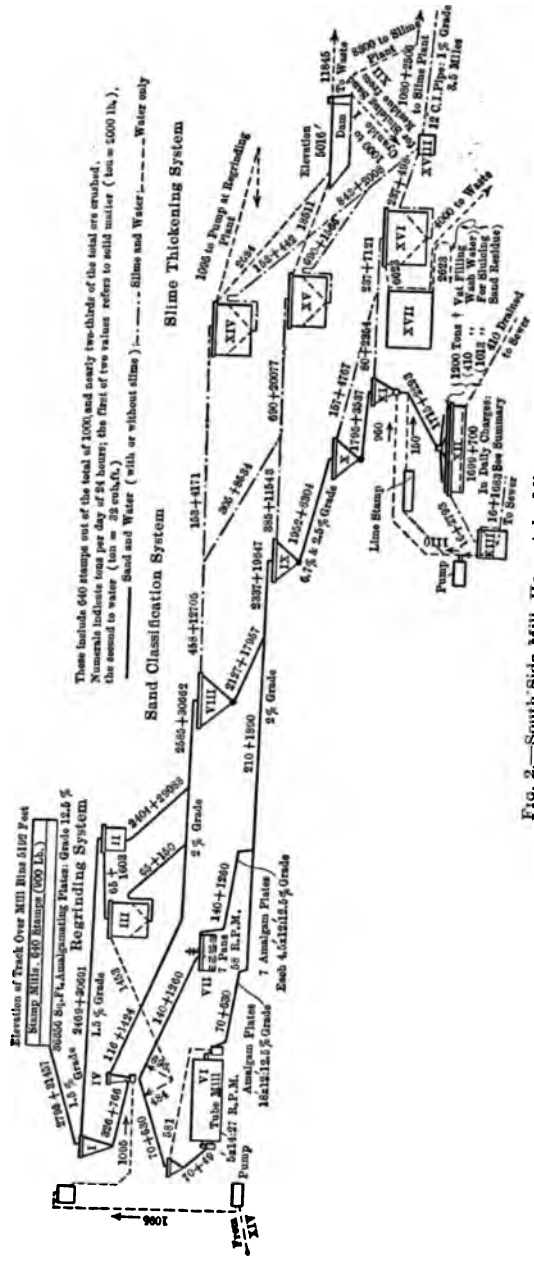


FIG. 2.—South Side Mill, Homestake Mine.

TABLE I.

| Reference. | Description. | Location. | Number Installed. | No. in Use when Tested. | Dimensions. | | | | Feed. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Diameter Inside. | Depth Inside. | Slope of Cone. | Diameter of Outlet. | Solid. | Water. |
| | | | | | Ft. | Ft. | ° | In. | Tons. | Tons. |
| I | Gravity cone | Regrinding Plant. | 14 | 14 | 4.0 | 5.5 | 70 | 0.56 | 2795 | 31,457 |
| II | Dewatering tank | | 1 | 1 | 12.0 | 12.0 | .. | .... | 2469 | 30,691 |
| III | Clarifying tank | | 2 | 2 | 18.0 | 20.0 | 45 | 0.63 | 65 | 1,603 |
| IV | Hydraulic concentrating cone | | 14 | 14 | 1.33 | 3.8 | 80 | 0.38 | 326 | 1,861 |
| V | Dewatering cone | | 1 | 1 | 3.0 | 2.6 | 60 | 0.50 | 70 | 630 |
| VI | Tube mill | | 1 | 1 | 5.0 | (14) | .. | .... | 70 | 49 |
| VII | Grinding pan | | 7 | 7 | 5.0 | 2.0 | .. | .... | 140 | 1,260 |
| VIII | No. 1 settling cone | Cone ho. 1 | 16 | 15 | 10.0 | 6.0 | 50 | 1.63 | 2585 | 30,662 |
| IX | No. 2 settling cone | Cone ho. 2 | 12 | 12 | 7.0 | 4.2 | 50 | 1.70 | 2337 | 19,847 |
| X | No. 3 settling cone | Cyanide 1. | 9 | 8 | 7.0 | 4.2 | 50 | 0.72 | 1952 | 8,304 |
| XI | Hydraulic sizing cone | | 36 | 32 | 3.5 | 3.0 | 60 | 0.60 | 1795 | 4,497 |
| XII | Sand vat | | 20 | 20 | 44.0 | 9.0 | .. | .... | 1715 | 2,293 |
| XIII | Clarifying tank | | 1 | 1 | 20.0 | 19.0 | 60 | .... | 16 | 2,793 |
| XIV | Thickening tank | Clar. ho. A | 4 | 3 | 26.0 | 19.0 | 45 | 0.63 | 153 | 4,171 |
| XV | Thick'g tanks large | Clar. ho. 1 | 9 | 9 | 26.0 | 19.0 | 45 | 0.63 | 491 | 13,653 |
| | Thick'g tanks medium | Clar. ho. 1 | 3 | 3 | 18.0 | 19.0 | 45 | 0.40 | 199 | 6,424 |
| | Thick'g tanks small | Clar. ho. 1 | 6 | 6 | 18.0 | 16.0 | 45 | 0.45 | | |
| XVI | Thickening tank | Clar. ho. 2 | 6 | 6 | 26.0 | 23.0 | 45 | 0.63 | 237 | 7,121 |
| XVII | Clear water tank | Cyanide 1 | 1 | 1 | 30.0 | 23.0 | .. | .... | ..... | 6,623 |
| XVIII | Slime mixing sump. | | | | | | | 12.0 | Mixed dis- | |

an interesting plant in that it combines cyanidation with amalgamation and concentration on a type of ore not formerly treated by cyanidation, namely, complex lead, zinc, silver-gold ores. No details of the mill are available.

The Smuggler Union Mill[1] at Telluride, Colo., has been entirely remodeled. The ore is crushed by stamps in water through 16-mesh screens, passed over amalgamated plates and through Pierce riffles to the first classifiers. The underflow from these goes to Wilfley tables producing concentrate, middlings and tailings. The tailings are sent to Akins' classifiers the underflow from which passes to sand tanks for leaching, while the overflow joins that from the Callow cones mentioned below. The middlings are reground in Hardinge tube mills and join the overflow from the first classifiers which passes to Callow cones, the overflow from which goes to Frue Vanners for the removal of concentrate. The overflow from the Callow cones joins the vanner tailings and the combined product goes to a Dorr thickener which removes a large part of the water, the thickened pulp passing to a Portland revolving filter, for a more complete removal of the water. The slime pulp from the filter is mixed with

[1] *Met. and Chem. Eng.*, X, 195.

TABLE I.—*Continued.*

| Feed. | | | | | | Overflow. | | | | | | | Discharge. | | | | | | | Approximate Elevation of Overflow above Sea.[1] | Reference. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Water Ratio. | Added Water included in Feed. | Sizing. | | | Gold Value per Ton. | Solid. | Water. | Water Ratio. | Sizing. | | | Gold Value per Ton. | Solid. | Water. | Water Ratio. | Sizing. | | | Gold Value per Ton. | | |
| | | Coarse: On 100. | Middle: 100–200. | Fine: Thro' 200. | | | | | Coarse: on 100. | Middle: 100–200. | Fine: Thro' 200. | | | | | Coarse: On 100. | Middle: 100–200. | Fine: Thro' 200. | | | |
| | Tons. | % | % | % | $ | Tons. | Tons. | | % | % | % | $ | Tons. | Tons. | | % | % | % | $ | Ft. | |
| 11.2 | ..... | 24 | 17 | 59 | 1.32 | 2469 | 30,691 | 12.4 | 18 | 18 | 64 | 1.20 | 326 | 766 | 2.34 | 71 | 14 | 15 | 2.09 | 5098 | I |
| 12.4 | ..... | 18 | 18 | 64 | 1.20 | 65 | 1,603 | 24.6 | 0 | 5 | 95 | 1.00 | 2404 | 29,088 | 12.1 | 18 | 18 | 64 | 1.21 | 5095 | II |
| 24.6 | ..... | 0 | 5 | 95 | 1.00 | ..... | 1,453 | ..... | ... | ... | ... | .... | 65 | 150 | 2.3 | 0 | 5 | 95 | 1.00 | 5092 | III |
| 5.7 | 1095 | 71 | 14 | 15 | 2.09 | 116 | 1,424 | 12.3 | 37 | 25 | 38 | 1.36 | 210 | 437 | 2.08 | 90 | 7 | 3 | 2.62 | 5094 | IV |
| 9.0 | 484 | 86 | 9 | 5 | 2.45 | ..... | 581 | ..... | ... | ... | ... | .... | 70 | 49 | 0.70 | 86 | 9 | 5 | 2.45 | 5085 | V |
| 0.70 | ..... | 86 | 9 | 5 | 2.45 | ..... | ..... | ..... | ... | ... | ... | .... | 70 | 630 | 9.0 | 19 | 29 | 52 | 1.87 | 5075 | VI |
| 9.0 | 969 | 91 | 6 | 3 | 2.70 | ..... | ..... | ..... | ... | ... | ... | .... | 140 | 1,260 | 9.0 | 25 | 30 | 45 | 2.04 | 5080 | VII |
| 11.9 | ..... | 19 | 18 | 63 | 1.21 | 458 | 12,705 | 27.7 | 0 | 0 | 100 | 0.98 | 2127 | 17,957 | 8.5 | 23 | 22 | 55 | 1.25 | 5080 | VIII |
| 8.5 | ..... | 23 | 23 | 54 | 1.32 | 385 | 11,543 | 30.2 | 0 | 0 | 100 | 1.00 | 1952 | 8,304 | 4.25 | 27 | 28 | 45 | 1.39 | 5066 | IX |
| 4.25 | ..... | 27 | 28 | 45 | 1.39 | 157 | 4,767 | 30.2 | 0 | 0 | 100 | 0.88 | 1795 | 3,537 | 1.97 | 30 | 30 | 40 | 1.43 | 5010 | X |
| 2.5 | 960 | 30 | 30 | 40 | 1.43 | 80 | 2,354 | 29.4 | 0 | 0 | 100 | 1.00 | 1715 | 2,143 | 1.25 | 32 | 31 | 37 | 1.47 | 5005 | XI |
| 1.34 | [2]1200<br>150 | 32 | 31 | 37 | 1.47 | 16 | 2,793 | 174.0 | ... | ... | 100 | 1.00 | 1699 | 700 | 0.41 | 32 | 31 | 37 | 0.38 | 4980 | XII |
| 174.0 | ..... | 0 | 0 | 100 | 1.00 | ..... | 1,110 | ..... | ... | ... | ... | .... | 16 | 1,683 | 105.0 | 0 | 0 | 100 | 1.00 | 4966 | XIII |
| 27.3 | ..... | 0 | 0 | 100 | 0.98 | ..... | 3,729 | ..... | ... | ... | ... | .... | 153 | 442 | 2.9 | 0 | 0 | 100 | 0.98 | 5077 | XIV |
| 27.9 | ..... | 0 | 0 | 100 | 0.99 | ..... | 12,524 | ..... | ... | ... | ... | .... | 491 | 1,129 | 2.3 | 0 | 0 | 100 | 0.99 | 5036 | XV |
| 32.6 | ..... | 0 | 0 | 100 | 0.99 | ..... | 5,987 | ..... | ... | ... | ... | .... | 199 | 437 | 2.2 | 0 | 0 | 100 | 0.99 | 5036 | |
| 30.3 | ..... | 0 | 0 | 100 | 0.92 | ..... | 6,623 | ..... | ... | ... | ... | .... | 237 | 498 | 2.1 | 0 | 0 | 100 | 0.92 | 5001 | XVI |
| ..... | ..... | ... | ... | ... | .... | ..... | 4,000 | ..... | ... | ... | ... | .... | ..... | 2,623 | ..... | ... | ... | ... | .... | 4998 | XVII |
| charge from XIV, XV & XVI sent directly to Slime Plant. | | | | | | | | | | | | | 1080 | 2,506 | 2.32 | 0 | 0 | 100 | 0.97 | 4984 | XVIII |

cyanide solution and passed to four 45×15-ft. Pachuca tanks arranged for either continuous or intermittent agitation. From the agitators the pulp passes to a second Dorr thickener the overflow from which after being clarified passes to zinc shaving precipitation, while the pulp is filtered in Portland revolving filters, the solution from which joins the overflow from the Dorr thickener.

E. W. Buskett[3] describes results of tests and proposed plant for the treatment of silver-bearing tailings from the Granite-bimetallic mine near Philipsburg, Mont. A. J. Clark and W. J. Sharwood[4] describe the milling practice at the Homestake Mine, Lead, S. D., in a highly interesting and detailed paper of considerable length. The flow sheet of the south side mills is given in Fig. 2. It is impossible to abstract the paper within the space allowed and the reader is of necessity referred to the original. Homestake practice has been referred to in previous volumes of the MINERAL INDUSTRY. Details referring to the flow sheet are found in the Tables I and II.

[1] Elevations are approximate; in batteries of cones, etc., set on a grade, differences of 3 ft. to 4 ft. occur values given ar those of highest units.
[2] Preliminary filling water, *see* Summary.
[3] *Min. and Eng. World*, XXXVII, 283.
[4] *Trans. Inst. Min. and Met., Bul.*, 98, 99, 100.

TABLE II.

| [1] Summary of Operations in Sand Vats, XII.—Collection Drainage, Direct Treatment and Discharge by Sluicing. | | Per Charge 8 hr. 20 min. | | Per Day of 24 hr. | | Water Ratio. |
|---|---|---|---|---|---|---|
| | | Solid. Tons. | Water. Tons. | Solid. Tons. | Water. Tons. | |
| Charging | Used to fill Leaching Vat preliminary to charging Sand Pulp | ..... | 417 | ..... | 1,200 | ..... |
| | Introduced during charging | 596 | 796 | 1,715 | 2,293 | ..... |
| | Vat, when charging is completed, contains | 590 | 243 | 1,699 | 700 | 0.41 |
| | Overflow to Tank XIII during charging | 6 | 970 | 16 | 2,793 | 1.64 |
| | Totals | 596 | 1,213 | 1,715 | 3,493 | 2.05 |
| Draining and Leaching | Wash-water added during treatment, the equivalent of which is eliminated as drainage, or as "Low Solution" | ..... | 142 to 190 | ..... | 410 to 550 | 0.24 to 0.32 |
| | Solution added during treatment and returned to circulation | ..... | 460 | ..... | 1,326 | 0.78 |
| Sluicing | Residue after treatment and ready for sluicing | 590 | 243 | 1,699 | 700 | 0.41 |
| | Water added for sluicing (from all sources) | ..... | 699 | ..... | 2,013 | 1.18 |
| | Sluiced residue going to sewer | 590 | 942 | 1,699 | 2,713 | 1.59 |

H. A. Megraw[2] describes cyanide practice in the Black Hills, S. D. The practice at the following mills is described: Wasp No. 2; Golden Reward; Trojan; Victoria; Lundberg, Dorr and Wilson, and Reliance. Nearly all of these have been described in previous volumes of the MINERAL INDUSTRY.

Jesse Simmons[3] describes the Victoria Mill, in the Ragged Top and Spearfish Canyon district in the Black Hills, S. D. The ore is crushed by gyratory crushers and rolls to pass a 6-mesh No. 14 wire screen, trommels being used for the screening. This coarse product is leached with strong and weak solution 3 and 1.5 lb. KCN, respectively. Precipitation is by zinc shavings. The extraction is stated to be 80 to 85 per cent. The Iola Cyanide Mill at Candor, N. C., is described by P. E. Barbour.[4]

**Canada.**—H. A. Megraw[5] describes cyaniding at the Dome Mill, near South Porcupine, Ontario, Canada. The flow sheet of this mill has been given.[6] Precipitate is refined into bullion by the Homestake method,[7] melting with lead and cupelling. The bullion from the cupelling furnace is melted in an oil-fired tilting furnace. Sixty-five per cent. of the gold content of the ore is recovered by amalgamation and 30 per cent. by

[1] In more recent practice (1910–11) these figures are modified. Slight changes in ore and adjustments result in throwing a rather larger proportion into the slime line, reducing the sand charge to about 1600 tons per day, or one charge of 590 tons in 8 hours 50 minutes, with a somewhat smaller percentage of "fine." This allows the 1200 tons of preliminary "filling water" to be mostly omitted, diminish ing the volume of overflow during charging, and reducing the overflow of solid to XIII. The slime going to XIII is now recovered. All above figures refer to period about March 1909, only.

[2] *Eng. and Min. Journ.*, XCIV, 1221.

[3] *Min. and Eng. World*, XXXVII, 571.

[4] *Eng. and Min. Journ.*, XCIV, 505.

[5] *Eng. and Min. Journ.*, XCIV, 983.

[6] MINERAL INDUSTRY, XX, 328

[7] A. J. Clark and W. J. Sharwood, *Trans. Inst. Min. and Met. Bul.*, 98.

cyanidation. It is of interest to compare practice at this mill with that at the Hollinger Mill, a description of which follows.

The Hollinger Mill[1] is described by H. A. Megraw. This is one of the new mills at Porcupine and treats approximately 400 tons of $20 ore per day, recovering 93 per cent. of the gold. The ore is a mixture of sericite schist and quartz containing a high percentage of pyrite. The gold is free. Fig. 3 gives the flow sheet of the mill. The ore is soft and comparatively easily crushed, yielding a heavy pulp (dry slime sp. gr. = 2.85) which gives rise to some mechanical difficulties in the treatment, particularly in agitation. About 4 tons of solution are precipitated per ton of ore treated and the zinc consumption is 0.8 lb. per ton of ore milled. Precipitate from the presses is smelted direct in graphite crucibles in an oil-fired Monarch tilting furnace, with the following flux: 20 per cent. borax, soda 7 per cent. and silica 3 per cent., weight of precipitate = 100. The resultant bullion is 760 fine. Features of the mill are: first, crushing in solution; second, extensive concentration to recover free gold; third, pan amalgamation of the concentrate; fourth, the use of Trent agitators for heavy pulp; fifth, the use of the Moore filter for heavy granular slime. The Trent agitators are not giving satisfaction on the heavy pulp, and concentration may in the future be dispensed with. This mill should be compared with the Dome Mill, treating similar ore and employing amalgamation plates, crushing in water, and Pachuca agitation tanks, no concentration, Merrill slime presses and the Homestake method of smelting precipitate. It would seem that amalgamation is preferable to concentration for the recovery of free gold.

S. N. Graham[2] briefly describes the 10-stamp mill of the McIntyre Porcupine Mines Ltd., near Porcupine. The mill treats Porcupine ores by amalgamation on plates followed by concentration. No cyanidation is practised. The Nipissing High-Grade Mill[3] of the Nipissing Mining Co. Ltd., of Cobalt, Can., is described by R. B. Watson. This remarkable mill, from the metallurgical standpoint, treats the high-grade silver ores (2500 oz. and more silver per ton) from the Nipissing Mines by a process combining amalgamation and cyanidation. Its design is largely the work of C. Butters and H. G. Clevenger. The ore consists mainly of the arsenides of cobalt and nickel in a calcite gangue, with a large amount of silver in the metallic state. A typical ore contains silver, 10 per cent.; cobalt, 9 per cent.; nickel, 6 per cent.; arsenic, 39 per cent.; and the balance, lime and silica with small amounts of iron, sulphur, antimony, tellurium, mercury, etc. Ore of this kind is unsatisfactory to market

[1] *Eng. and Min. Journ.*, XCIV, 1173; W. R. Ingalls, *Eng. and Min. Journ.*, XCIII, 645, and *Canadian Min. Journ.*, XXXIII, 230.
[2] *Canadian Min. Journ.* XXXIII, 233.
[3] *Eng. and Min. Journ.*, XCIV, 1077, and H. A. Megraw, *Eng. and Min. Journ.*, XCIV, 1127.

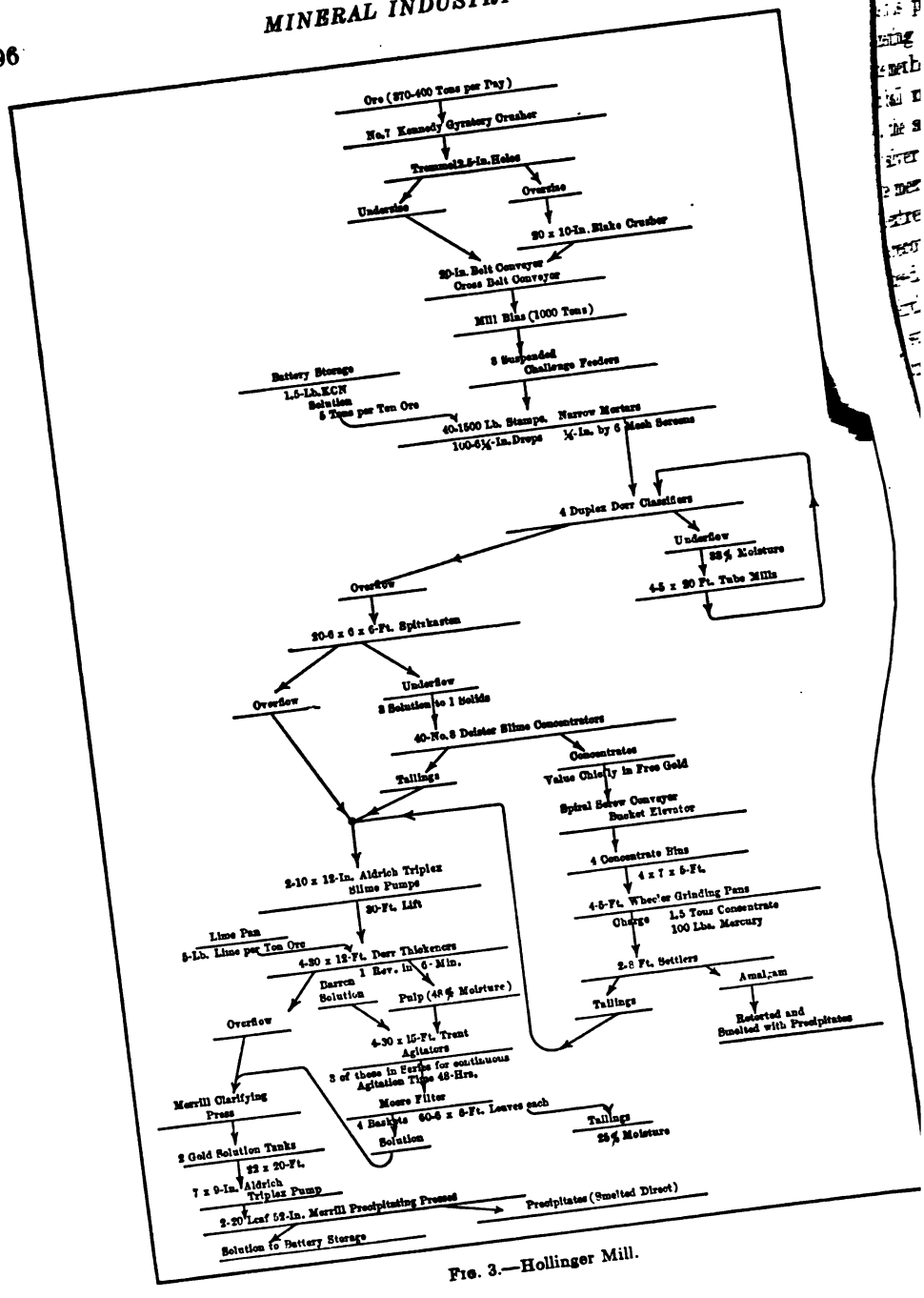


FIG. 3.—Hollinger Mill.

as it is practically impossible to sample properly, aside from the high smelting charges imposed. The accompanying flow sheet, Fig. 4, gives the method of treatment. The features of the mill are: (1) the grinding in ball mills, recovering coarse silver, and obtaining a uniform pulp; (2) the amalgamation of the pulp with 15 parts of mercury for each part of silver, in strong cyanide solution in a tube mill. This probably keeps the mercury bright and prevents its flouring and sickening, for the ore is extremely base. From 97 to 98 per cent. of the total silver in the ore is recovered as amalgam from the tube mill. Compressed air is introduced into the tube mill through one of the trunnions, to aid in the solution of some of the silver. (3) The treatment with cyanide solution of such a base pulp. The solutions become very foul as may be seen from the analysis of a precipitate which settles out in the stock tank: Ag, 0.394 per cent.; Hg, 2.51 per cent.; Sb, 3.30 per cent.; S, 16.13 per cent.; As, 32.64 per cent.; $SiO_2$, 5.362 per cent.; Zn, 2.57 per cent.; Fe, 5.04 per cent.; Ni, 9.06 per cent.; Co, 7.03 per cent.; CaO, 9.24 per cent.; $CO_2$, 7.259 per cent.; Mn, trace. This points to the fact that most of the constituents of the ore are attacked by the solution. A very small percentage only of the silver in the ore is recovered by cyanidation. There is much evidence that mercury or mercury compounds (probably silver amalgam) occur in the ore, usually from 2 to 5 lb. in each ton of ore. (4)The great amount of amalgam handled and the method of refining it. Considerable trouble is experienced in obtaining retorts to stand the hard service. A cast steel retort so far has proven most efficient. The amount of silver handled is so great that no lead need be used in any part of the refining. The sponge is refined by oxidation in the reverberatory furnace, the skimmings, very rich in silver and consisting chiefly of nickel and cobalt oxides are remelted in a blast furnace with the cyanide precipitate, the base metals being removed in the slag, while the precious metal is recovered as bullion. This part of the mill presents a decidedly new thing in the metallurgy of silver. The bullion from the reverberatory furnace is stated to be 999 fine, which is remarkable. Shipments of silver amount to 370,000 oz. per month.

H. A. Megraw[1] describes in considerable detail the cyanide milling practice in the Cobalt district. Four mills practise cyanidation in some form; the Nipissing Mining Co., the Buffalo Mines Co., the Dominion Reduction Co., formerly the Nova Scotia, and the O'Brien Mine. The Nipissing Mines Co. has recently completed a new mill to treat its low-grade ores (25 to 35 oz. Ag per ton). The ore is crushed and then jigged to take out coarse silver, the concentrate being sent to the high-grade mill while the tailings are crushed by forty 1500-lb. stamps, in

[1] *Eng. and Min. Journ.*, XCIV, 837.

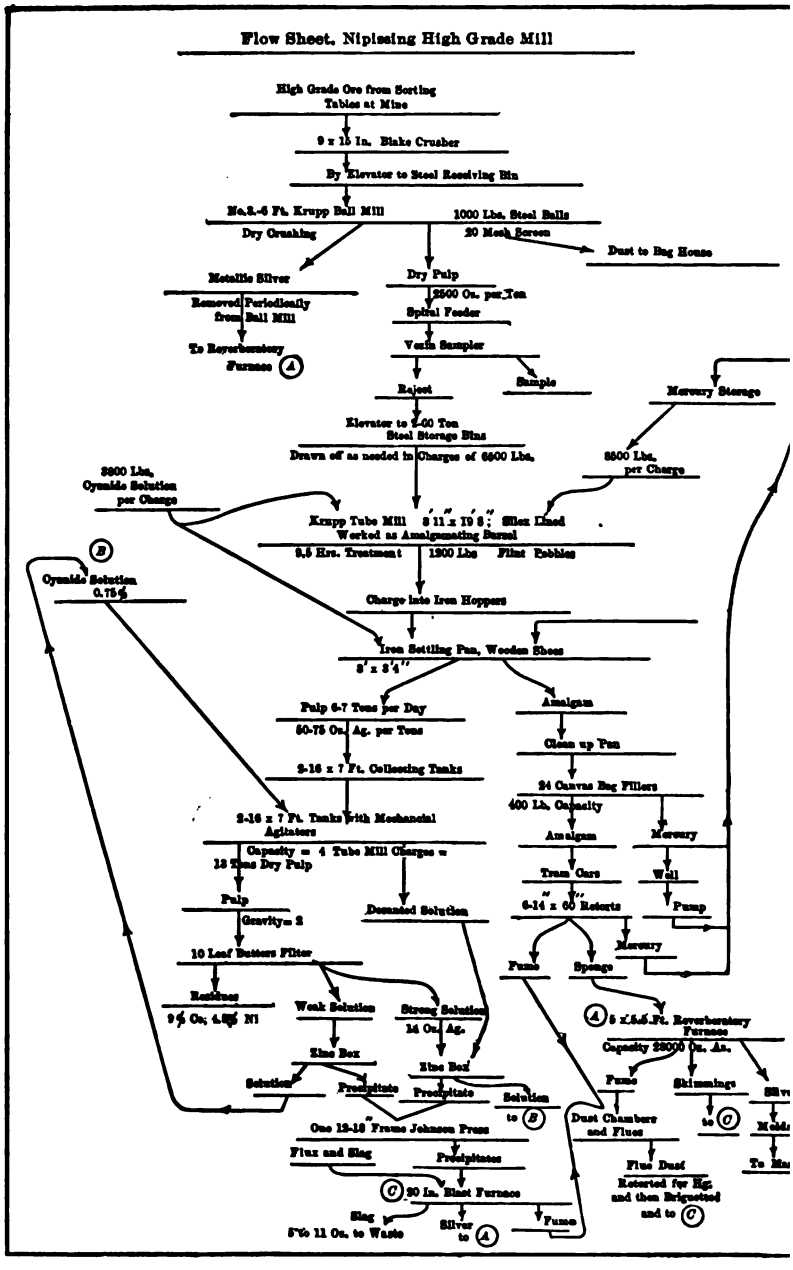
Flow Sheet, Nipissing High Grade Mill
High Grade Ore from Sorting Tables at Mine
9 x 15 In. Blake Crusher
By Elevator to Steel Receiving Bin
No.2-6 Ft. Krupp Ball Mill
1000 Lbs. Steel Balls
Dry Crushing
20 Mesh Screen
Dust to Bag House
Metallic Silver
Removed Periodically from Ball Mill
To Reverberatory Furnace A
Dry Pulp
2500 Oz. per Ton
Spiral Feeder
Vezin Sampler
Reject
Sample
Mercury Storage
Elevator to 2-60 Ton Steel Storage Bins
Drawn off as needed in Charges of 6500 Lbs.
6500 Lbs. per Charge
2600 Lbs. Cyanide Solution per Charge
Krupp Tube Mill 8'11" x 19'8" Silex Lined Worked as Amalgamating Barrel
3.5 Hrs. Treatment
1200 Lbs Flint Pebbles
B
Cyanide Solution 0.75%
Charge into Iron Hopper
Iron Settling Pan, Wooden Shoes 8' x 8'4"
Pulp 6-7 Tons per Day
50-75 Oz. Ag. per Tons
Amalgam
Clean up Pan
2-16 x 7 Ft. Collecting Tanks
24 Canvas Bag Filters 400 Lb. Capacity
2-16 x 7 Ft. Tanks with Mechanical Agitators
Capacity = 4 Tube Mill Charges = 13 Tons Dry Pulp
Amalgam
Mercury
Tram Cars
Well
Pulp
Gravity = 2
Decanted Solution
6-14 x 60" Retorts
Pump
10 Leaf Butters Filter
Mercury
Fume
Sponge
Residues
9% Oz. 4.85% Ni
Weak Solution
Strong Solution 14 Oz. Ag.
A 5 x 5.5 Ft. Reverberatory Furnace
Capacity 25000 Oz. Ag.
Zinc Box
Zinc Box
Solution
Precipitate
Precipitate
Solution to B
Fume
Skimmings
to C
One 12-16" Frame Johnson Press
Dust Chambers and Flues
Flux and Slag
Precipitates
Flue Dust Roasted for Hg. and then Briquetted and to C
C 30 In. Blast Furnace
Slag 5% to 11 Oz. to Waste
Silver to A
Fume

FIG. 4.

solution. Tube mills, Dorr classifier and thickeners, mechanical agitators, vacuum filters and aluminium dust precipitation are employed. A feature of the mill is the absence of concentration. The Buffalo Mines Co., is erecting a high-grade mill similar to that of the Nipissing Co. It differs from this mill in using Parral agitators and a Perrin filter press for the slime pulp.

W. J. Dobbins and H. G. S. Anderson[1] describe the practice at the Buffalo Mines Co.'s mill in some detail. The mill employs an elaborate system of concentration and cyanidation. The ore is crushed in water by rolls and Chilean mills. Sand tailings from the concentrators are stored and not cyanided at present. Slime is thickened in Dorr settlers. Continuous agitation in Pachuca tanks has been replaced by intermittent agitation. The pulp is filtered in vacuum filters.

C. L. Hargrave[2] discusses cyanidation at the Nova Scotia Mill, now the Dominion Reduction Co. mill at Cobalt, Canada. This mill crushes in solution by stamps, and tube mills, concentrates sand and slime on tables, and cyanides slime by agitation and filters the pulp in vacuum filters. The mill has recently been remodeled. Cyanidation at Cobalt is still in a large measure in the experimental stage and changes in practice are constantly being made. The different mines have ores that vary much in their characteristics as may be judged by the fact that some mills employ concentration only, some concentration and cyanidation, others cyanidation only, and some amalgamation and cyanidation. A small part only of the total output of the district is recovered by cyanidation. The complex nature of the ore makes its treatment by cyanidation difficult and chemical troubles are frequent. Cyanide consumption is high, from 3 to 6 lb. per ton of ore treated.

E. Jacobs[3] briefly describes the gold mills of British Columbia.

**Mexico.**—D. L. H. Forbes[4] describes the treatment of complex silver-gold ores at the Lucky Tiger Mine, El Tigre, Sonora, Mexico. The plant treats 175 tons of ore and 75 tons of old tailings per day. The ore is complex in mineral character, containing aside from the silver minerals, zinc blende, chalcopyrite, bornite, galena, pyrite, etc., in appreciable amount, making concentration essential before cyanidation. The ore on an average contains about 0.25 oz. gold and 34 oz. silver per ton. It is concentrated in two mills, one an old one of 55 tons per day capacity and the other, a new one of 125 tons capacity. The tailings from these together with 75 tons old tailings pass to the cyanide plant where crushing is done in five 5×14 ft. tube mills, so that 80–85 per cent. of the product passes a 200-mesh screen. The accompaning flow sheet, Fig. 5, outlines the

[1] *Eng. and Min. Journ.*, XCIV, 211.
[2] *Eng. and Ming. Journ.*, XCIII, 1133.
*Canadian Min. Journ.*, XXXIII, 86.
[4] *Trans. A. I. M. E., Bul.* 68, 769, Aug., 1912.

practice. The paper contains valuable detail, some of whicl referred to under slime treatment and precipitation, further article.

D. F. Irvin[1] describes the method adopted to store tailir Lucky Tiger Mine, to prevent pollution of streams and dama cultural interests.

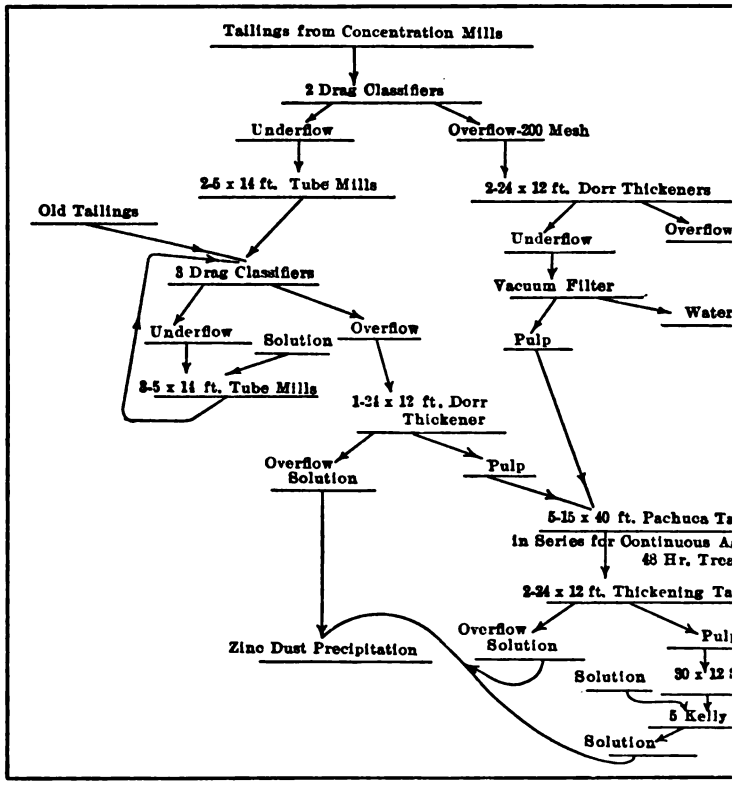


FIG. 5.—Lucky Tiger Mill.

Bernard MacDonald[2] describes the new cyanide mill of Colorado Mining and Smelting Co. at Parral, Chihuahua, Mex went into operation in Feb., 1911. The ore has this composit 69 per cent.; $Fe_2O_3$, 3.60 per cent.; $Al_2O_3$,9.00 per cent.; Zn cent.; Pb, 0.03 per cent.; Mn, trace; Cu, none; Ag, 12.5 oz. pe trace. The silver occurs mainly as sulphide, but in part a and bromide. The flow sheet of the mill is shown in Fig. 6. requires 603 h.p. which is 83 per cent. of the rated capacity

[1] *Min. and Sci. Press*, CV, 727.
[2] *Min. and Sci. Press*, CV, 4 and 40.

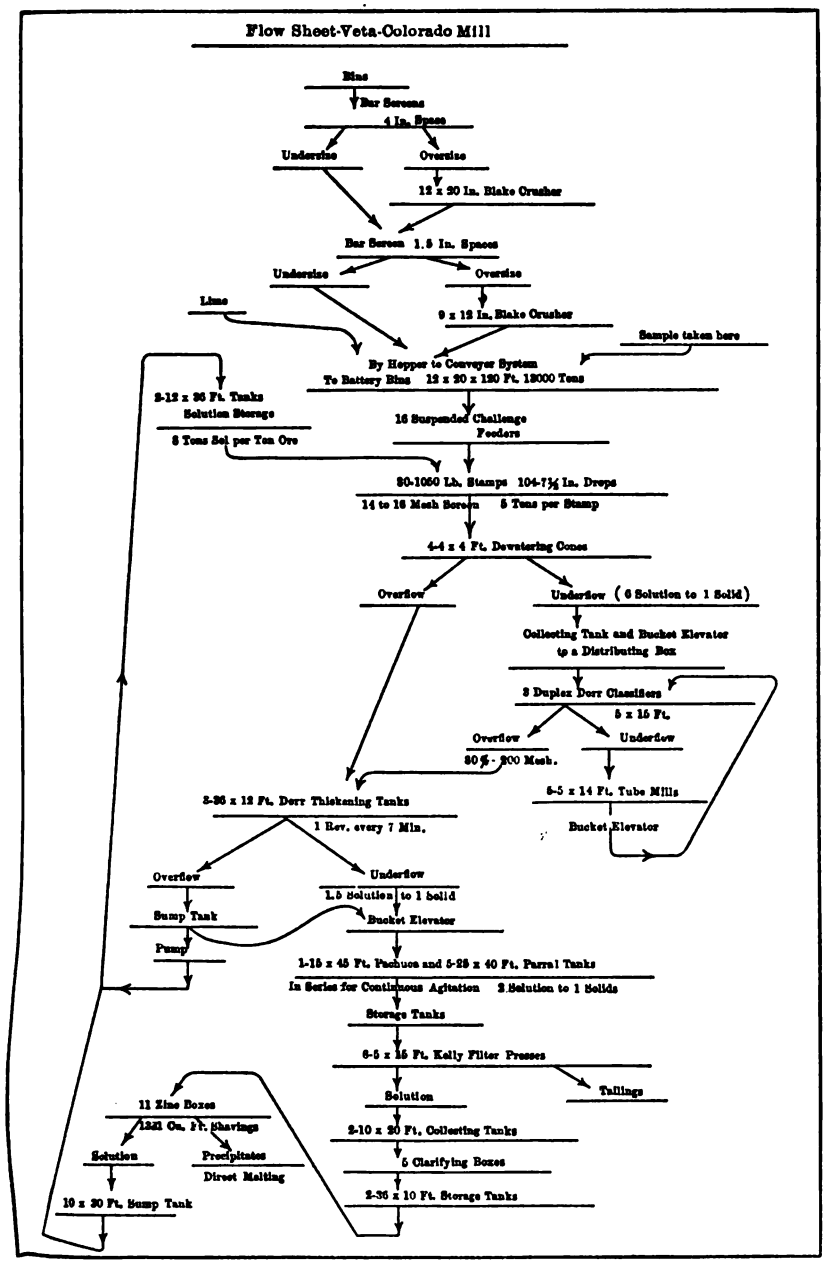
Flow Sheet-Veta-Colorado Mill
Bins
Bar Screens
4 In. Space
Undersize
Oversize
12 x 20 In. Blake Crusher
Bar Screen 1.5 In. Spaces
Undersize
Oversize
Lime
9 x 12 In. Blake Crusher
Sample taken here
By Hopper to Conveyor System
To Battery Bins 12 x 20 x 120 Ft. 12000 Tons
2-12 x 36 Ft. Tanks
Solution Storage
8 Tons Sol per Ton Ore
16 Suspended Challenge Feeders
80-1050 Lb. Stamps 104-7⅛ In. Drops
14 to 16 Mesh Screen 5 Tons per Stamp
4-4 x 4 Ft. Dewatering Cones
Overflow
Underflow ( 6 Solution to 1 Solid)
Collecting Tank and Bucket Elevator
to a Distributing Box
2 Duplex Dorr Classifiers
5 x 15 Ft.
Overflow
Underflow
80 % - 200 Mesh.
8-5 x 14 Ft. Tube Mills
Bucket Elevator
2-36 x 12 Ft. Dorr Thickening Tanks
1 Rev. every 7 Min.
Overflow
Underflow
1.5 Solution to 1 Solid
Sump Tank
Bucket Elevator
Pump
1-16 x 45 Ft. Pachuca and 5-28 x 40 Ft. Parral Tanks
In Series for Continuous Agitation 2 Solution to 1 Solids
Storage Tanks
6-5 x 15 Ft. Kelly Filter Presses
Solution
Tailings
11 Zinc Boxes
1221 Cu. Ft. Shavings
Solution
Precipitates
Direct Melting
10 x 30 Ft. Sump Tank
2-10 x 30 Ft. Collecting Tanks
5 Clarifying Boxes
2-36 x 10 Ft. Storage Tanks

FIG. 6.

meters used or 1.5 h.p. per ton of milling capacity. The article gives interesting detail some of which is referred to under other captions.

E. Grandi[1] describes the Purisima Grande Mill, Pachuca, Mexico. The 100-ton mill treats Pachuca silver ore. The ore is crushed in solution 1.2 per cent. cyanide by five slow speed Chilean mills. Each mill has 2 rollers 1.5 meters in diameter and weighing 4080 kg. when new. Six cu. m. of solution are used per ton of ore. The discharge from the mills is concentrated on Wilfley tables which recover 18 per cent. of the ore value in 0.5 per cent. of the weight of the ore. The tailings from the tables are passed to two Dorr classifiers, the underflow reground in two Krupp tube mills and the whole product treated in a Dorr thickener, four Pachuca tanks and a Moore filter of two sets of twenty 10×6 ft. leaves. Zinc shaving precipitation is used. The precipitate is melted direct. The power consumption of the mill is 2.07 h.p. per ton treated.

A. L. Sweetser[2] describes the 200-ton cyanide mill of the New York Honduras Rosario Min. Co. near San Juancito, Honduras. The ore is rather complex and contains about 25 oz. silver and 0.46 oz. gold per ton. The mill equipment consists of 20 stamps (1850 lb.), three Dorr classifiers, three 22×5 ft. tube mills, thickening tanks, Pachuca agitating tanks, two Merrill slime presses and the zinc dust precipitation system.

**South America.**—R. W. Perry[3] describes in detail the cyanidation of old tailings, about 40 miles north of Medellin, in Colombia. The article gives interesting details concerning the construction of cheap plants, and costs.

**South Africa.**—R. Gascoyne[4] describes the new mill of the Modderfontein B Company the flow sheet of which has been given.[5] Efforts are now being made to work out a process for the treatment of the older and more valuable tailings dumps on the Rand.[6] H. S. Gieser[7] describes the Benoni Consolidated Mill on the far east Rand, previously referred to.[8]

**Australia.**—A. W. Longbottom[9] describes the cyanidation of antimonial tailings in the Hillgrove district, N. S. W.

C. A. Banks[10] describes an interesting and novel tailing plant on the Shinemuri River, New Zealand. The plant is owned by the Waihi-Poeroa Gold Extraction Co. of Auckland. The tailings have accumulated in the river for 20 years from the mills in the Karangahaki and Waihi districts. To remove the sand a dredge with an air lift is used. This

[1] *Trans. Mex. Inst. Min.* and *Met.*, II, No. 6; *Min. and Sci. Press*, CIV, 433.
[2] *Min. and Sci. Press*, CV, 752.
[3] *Eng. and Min. Journ.*, XCIII, 498.
[4] *Min. and Eng. World*, XXXVI, 953.
[5] MINERAL INDUSTRY, XX, 332
[6] *Min. and Eng. World*, XXXVI, 772.
[7] *Eng. and Min. Journ.*, XCIV, 23, and *Min. and Sci. Press*, CIV, 723.
[8] MINERAL INDUSTRY, XX, 334
[9] *Min. and Sci. Press*, CIV, 884.
[10] *Min. Mag.*, VII, 121.

has a capacity of 100 tons per hour and can lift from a maximum depth of 26 ft. The dredge discharges into four 70-ton barges which are unloaded at the wharf by means of a 20-in. bucket swinging elevator, with 40-ft. centers. The elevator delivers the sand through a rotary screen for separating rubbish, into a reinforced concrete storage tank of 3000 tons capacity. The sand is lifted from the storage plant by a small air lift and flows to the boot of a 12-in bucket elevator which delivers it to the distributing box for ten 6 ft. Frue vanners. This separates the quartz tailing sand from the lighter river sand and charcoal present, the latter derived from the ashes discharged into the river. The cleaned quartz passes over the heads of the vanners in a layer about 0.25 in. deep which is flushed by a spray of weak cyanide solution. The sand is then lifted by a 12-in. bucket elevator to a storage tank, from which it is taken by an air lift to a distributing pan from which launders charge it to twenty 16×4 ft. tube mills. These tube mills are driven by gear and pinion in a novel manner, for a description of which reference should be made to the original paper. The product from the tube mills flows to a central sump from which elevator wheels lift it 35 ft. to the classifying cones, which overflow material finer than 200 mesh, while the underflow is returned to the tube mills. The elevator wheels are of novel design, and and handle 3500 tons of sands and 5000 tons of solution per day, although the plant treats but 500 tons tailings. The extra tonnage on the wheels and tube mills is due to the large amount of oversize returned to the tube mills. The slime from the classifiers is mixed with lime and passed to four 20 ft. conical bottom thickening vats, from which it is pumped by centrifugal pumps to fifteen 13×50 ft. agitating tanks of the Pachuca type, where it receives 48 hours agitation. From here it passes to a vacuum filter, evidently a modified Moore type, which has a filtering area of 1660 sq. ft. A 1.5-in. cake is formed. The solution from the filter passes to gold storage tanks and is then precipated by zinc shavings. The average assay value of the tailings in the river is $2.75 per ton and the refuse from treatment contains about 60 cents. The plant cost about $350,000.

Cyanidation at the Talisman mine, near Karangahake, New Zealand, is described by Arthur Jarman.[1] The gold-silver ore, rather complex in character is crushed by Blake crushers and stamps, the pulp classified and the coarse reground in tube mills. Amalgamation is done after tube milling. From the amalgamation plates the pulp passes for concentration to vanners. Sand is treated by percolation and slime by agitation and vacuum filtration. Precipitation is carried out by zinc shavings.

[1] *Proc. Aus. Inst. Min. Eng.*, Sept. 30, 1911; *Met. and Chem. Eng.*, X, 242.

M. W. Von Bernewitz[1] describes stamp milling and amalgamation practice at Bendigo, Victoria. The practice is still the old fashioned but evidently efficient one in use for many years. At Leggo's concentrate plant arsenical pyrite concentrate from the various mines is roasted and then cyanided.

M. W. von Bernewitz[2] describes the mill of the Mountain Queen mine near Southern Cross, and that of the Yuanmi mine in the East Murchison, Western Australia. The first employs a Holman pneumatic stamp, grinding pans and amalgamation plates, and the second, stamps crushing in solution, tube mills, agitators and a vacuum filter of the Butters type.

The same author[3] describes ore treatment at the Associated mine, Kalgoorlie, which has been previously referred to.[4] The article gives valuable detail of ball mill crushing and pan amalgamation, and the roasting of ores, which will be again referred to. Crushing for cyanidation in Huntington mills at Kalgoorlie is described by the same author.[5]

P. R. Fanning[6] describes the mill of the Colorado Mining Company, Philippine Islands. The ore is rough crushed in a 20×10 in. Blake crusher and passes to twenty 1250-lb. stamps crushing in 0.12 to 0.20 lb. KCN solution. With a 6-mesh screen the capacity is 4.5 tons per stamp. The pulp, 6 parts solution to 1 ore, passes to a Dorr classifier, the sand from which is reground in two 5×18 ft. tube mills. The slime overflow goes to a 20×14 ft. Dorr thickener, the overflow from which after clarification in a sand filter, goes to zinc shaving precipation. The thickened pulp (1.5 to 1) passes to two 12×40 ft. Pachuca tanks for agitation, from which it goes to a second Dorr thickener for dilution and decantation. The pulp from this goes to a 20×18 ft. Traylor agitator which prepares it for filtering by two 11.5×8 ft. Oliver continuous filters. The solution from the filters is divided between the battery storage tank for use in dilution in the second Dorr thickener.

## Slime Treatment

*General.*—There is still considerable discussion, intensified by the recent court decision in favor of the Moore Filter Company, about the advisability of replacing filtration by a system of continuous decantation.[7] There is perhaps no question but that with the improved thickening apparatus now in use decantation is more efficient than formerly, but the vast experience that has been gained with decantation in all its forms in

[1] *Min. and Sci. Press*, CV, 200.
[2] *Min. and Sci. Press*, CV, 148.
[3] *Min. Mag.*, VI, 127.
[4] Mineral Industry, XVI, 538.
[5] *Min. and Sci. Press*, CV, 618.
[6] *Min. and Sci. Press*, CV, 563.
[7] *Eng. and Min. Journ.*, XCIV, 1014, and A. W. Allen, *Min. Mag.*, VI, 43.

South Africa and elsewhere leads one to believe that as a distinct method of slime treatment it is a thing of the past. The advent of the Moore and Butters filter, and of the Merrill press marked a great advance in the metallurgy of gold and silver from which there will be no reversion to obsolete methods, by the great number of operators. This question has been previously discussed.[1] Another question that is frequently referred to is that of the complete elimination of sand leaching, and the treatment of all the ore as slime.[2] Usually this discussion is placed on too broad a basis, assuming that all ores are more or less alike, and will yield greater recoveries by very fine crushing of all the ore. This is not true as may be shown by many examples, notably the Rand and South Dakota. The question at an individual mine usually resolves itself into the relative cost of sand leaching and slime treatment. Where water under pressure is cheaply available to discharge tailings, the cost is usually less for sand treatment. At the Homestake mines the cost is about the same, 20 cents per ton for sand or slime treatment, but this case is exceptional in that no agitation with its consequent high power costs, need be used in the slime treatment. Any degree of crushing, therefore, finer than necessary to obtain the *economic extraction*, will add to cost in two ways, first, increased crushing cost and second, increased cost due to the higher treatment cost for slime over sand. The problem was discussed by E. M. Hamilton[3] some years ago. This same question is brought up for the Rand by H. Stadler.[4] He gives data tending to show the old single-stage stamp mill crushing through 35-mesh screens with a considerable portion of the pulp coarser than it is now with the stage crushing by stamp and tube mills, gave lower working costs, and greater net profits. The small increase in extraction gained by finer crushing is more than offset by the increased cost. A summary of his data is as follows:

| Mill. | Tonnage per Year. | Grading, Per Cent. | Recovery. | | | Reduction Cost. |
|---|---|---|---|---|---|---|
| | | | Cyanidation. | Amalgamation. | Total. | |
| New Kleinfontein single stage..... | 1910<br>466,882<br>$7.27 per ton. | +60, 18%; +90, 22%; +200, 14%; −200, 46% | 31.44<br>85.6[5] | 63.06 | 94.5% | $1.106 |
| East Rand Prop. double stage. | 2,126,334<br>$7.22 per ton. | +60, 3%; +90, 10%; +200, 23%; −200, 64% | 42.74<br>85.70[5] | 50.11 | 92.85% | 1.331 |
| Crown Mines double stage. | 1,514,000<br>$8.62 per ton. | +60, 5%; +90, 15%; +200, 12%; −200, 68% | 28.00<br>88.30[5] | 68.20 | 96.2% | 1.395 |

[1] MINERAL INDUSTRY, XX, 341.
[2] *Eng. and Min. Journ.*, XCIV, 771.
[3] MINERAL INDUSTRY, XVIII, 347.
[4] *Min. and Sci. Press*, CV, 78.
[5] Actual recovery by cyanidation calculated from heads to cyanide plant and tailings assay.

He does in no way condemn stage crushing and tube mills but contends that the crushing has been carried too far.

A patent decision of great interest in reference to slime filtration has been rendered by the U. S. Circuit Court of Appeals for the Third Circuit in the case of the Moore Filter Company *vs.* the Tonopah-Belmont Development Co., in effect the Moore filter *vs.* the Butters filter.[1]

The decision upholds the validity of the U. S. Patent 764486 granted on July 5, 1904, to George Moore and also declares that the Butters Filter infringed claims four and five of this patent. The decision is sweeping. It upholds the broadly claimed process of slime filtration outlined by Mr. Moore in his patent specifications. Judge Buffington states as follows: "We have reached the conclusion that this process is a radical departure from the whole prior art and was an original and pioneer step in metal recovery by filtration." The decision of a Court of Appeals in a patent case is commonly final in present practice. While the decision of the Circuit Court of Appeals is binding as legal precedence only within the jurisdiction of that particular court, it is the opinion that the chances for another Circuit Court of Appeals considering the case is very remote. It is probable that the slime filter case may now be considered settled. The decision is so sweeping that it involves all vacuum filters. It probably has no effect on pressure filters such as the filter press which were used long previous to Moore's patent.

Bernard Macdonald[2] discusses air-agitation and particularly the Parral tank system of air agitation. Pulp for agitation usually contains 1 to 2 parts of solution per 1 ton of dry slime. Two of solution to one of ore by weight is equivalent to about 5 to 1 by volume. For perfect agitation this ratio should be maintained in all parts of the agitator, during the whole of the treatment, and any agitator that permits a local thickening of the pulp, which usually happens in the lower part of the apparatus, fails to fully perform its function. He states that the common conception of the air-lift agitator is that the flow of air into the lift is continuous and that the lifting effect is produced by the formation of a large number of bubbles in the pulp of the lift tube, making it lighter and consequently subject to displacement by the heavier pulp in the tank outside which rushes in at the bottom, and causes the discharge of the lighter pulp at the top of the lift tube. What really takes place according to Mr. McDonald is that the air entering the lift tube assumes the form of bubbles, which uniting make a large flattened bubble or disk of air extending to the sides of the pipe rise to the surface pushing the

[1] *Eng. and Min. Journ.*, XCIV, 878, 917, 923; *Min. and Sci. Press*, CV, 517, 649, 663; *Min. and Eng. World*, XXXVII, 945; *Met. and Chem. Eng.*, X, 791.

[2] *Trans. A. I. M. E., Bul.*, 64, 387, and *Met. and Chem. Eng.*, X, 434, *Min. and Sci. Press*, CV, 42; *Eng. and Min. Journ.*, XCIV, 361.

pulp before it. The air valve acts intermittently, opening and closing, by momentary differences of pressure set up by the violent inrush of pulp into the air lift. In the Pachuca tank the end of the compressed air pipe in the lift tube is capped and for a length of about 7 in. next to the cap is perforated by a number of small holes through which the air escapes. To prevent the pulp from entering these holes and choking the pipe, when the air is shut off, a tight fitting rubber stocking or tube is drawn over the holes and clamped to the pipe above them. When the air is on, this stocking expands and the air flows underneath it and escapes at its lower end which is left open. The principal defect of this valve is the large amount of ineffective work that must be done by the numerous jet-like escapes of the compressed air. Moreover, the numerous alternate openings and closings of the rubber stocking soon destroy its elasticity and wear it out. In the Parral tank this device is replaced by a ball valve. This valve consists of a steel ball 2 in. in diameter which rests on a ground annular seat terminating the air pipe in the lift. It is held in place by an open hemispherical cap or grid which prevents the ball from being much displaced from its seat. The seat area of the valve is the only portion unbalanced, and the amount of useless work performed is much less than in the case of the Pachuca sleeve. The present Parral tank[1] is flat bottomed, 25 ft. in diameter and 42 ft. high, with a capacity three times as great as the standard Pachuca. For the transfer of pulp from the bottom to the top of the tank four 12 in. transfer or lift pipes are set 12 in. from the bottom and 4 ft. from the side of the tank and equidistant from each other. These pipes are set on spiders so as to admit the pulp to them. Into them project the compressed air pipes fitted with the ball valve described above. On the top ends of the lift pipes, tees of equal diameter are bolted with the run in line with the pipes and the outlets so directed as to discharge the pulp in line of segment chords to the circumference of the tank. The force of the discharge sets up a spiral or rotary flow in the tank charge which in a short time extends down to the bottom of the tank.

One of the difficulties met with in Pachuca tank practice is stated to be the settling of the pulp in the lower part of the tank and remaining inactive. It would seem that the design of the Pachuca tank with its cone bottom and position of lift would avoid the difficulty of pulp settling to a much greater degree than the large flat bottomed Parral tank. Data given on the efficiency of the Parral tank is not conclusive. No figures are available as to the amount of air used. The Pachuca tank is no doubt costly to install, but in spite of much criticism directed against it, is the most efficient agitator at present in general use.

[1] Mineral Industry, XIX, 305.

A. W. Allen[1] discusses the air lifting of slime pulp considering the following essential factors: (1) submergence; (2) air supply, (3) discharge arrangements, (4) air pressure, (5) air volume, (6) velocity of flow.

E. J. Laschinger[2] critically discusses the air-lift agitation of slime pulp giving full data on the mechanics of the problem. The Hendryx agitator was experimented with by the Mines Trials Committee of the Rand, South Africa.[3] This agitator is well known in this country. The results point to an extraction of the gold in less time, but with an increased power consumption, while operating, than is the case for the air-lift agitator, or for circulation by centrifugal pumps. The cost of increased power consumption may be compensated for by the shorter time of agitation necessary. The P. K. Wood cyanide agitator[4] consists of a tank with a conical bottom and a centrally placed lift pipe in which is operated from above, a shaft to which are attached a number of blades or impellers, that lift the pulp and discharge it at the top of the lift pipe.

H. R. Conklin[5] describes a system of piping for continuous agitation in air-lift agitators. The system was applied to five 24×32 ft. tanks. A straight line of 4-in. pipe, grade 8 in. in 24 ft. passes through the tanks. In the first tank the pipe enters at the top and leaves on the other side, 8 in. below the top. In the fifth tank the exit is 40 in. below the top. Connections through the tank are made by flanges. In the pipe in each tank, 5 in. from the entrance side,is threaded a tee, pointing down, and immediately following it a gate valve. Directly past the air lift, the pipe has in it a 12×1.5 in. slot, into which falls part of the slime discharge from the lift and passes to the next tank. The pulp enters the tank through the tee, and when it is desired to by-pass a tank, a plug is screwed into the tee while a wooden plug is fitted to the slot, the gate valve being opened. The pipe may be easily cleaned through the slots by means of high-pressure water. A simple tank for agitating the circulating solutions is proposed by J. E. Rothwell.[6]

J. E. Alley[7] describes a method for starting agitation in small Pachuca tanks treating concentrate at the Homestake mine, Neal, Idaho. The tanks are 5 ft. 8 in.×15 ft. A 17-ft. 1-in. pipe with a perforated sleeve at the lower end is attached to an air hose, and dropped into the lift tube. It rapidly works itself down and in 15 minutes the pulp is stated to be in thorough circulation.

[1] *Min. Mag.*, VI, 284.
[2] *Mines and Minerals*, XXXII, 239; *Journ. Chem., Met and Min. Soc., South Africa*, XI, 501.
[3] *South Africa Min. Journ.*, July 27, 1912; *Min. Mag.*, VII, 228.
[4] *Min. and Eng. World*, XXXVI, 375.
[5] *Eng. and Min. Journ.*, XCIII, 591.
[6] *Min. and Sci. Press*, CIV, 540.,
[7] *Min. and Sci. Press*, CV, 118.

J.W. Fairfield[1] has obtained a patent on an agitating, classifying and filtrating tank for testing ores by cyanidation.

C. C. Hafer[2] has patented an agitator which embodies the principles of the ordinary rotor agitator and the air-lift agitator. It presents nothing essentially new. Laboratory agitation apparatus is described by W. H. Coghill,[3] E. W. Buskett,[4] and John Randall.[5] J. L. Mennell[6] describes a flow sheet for a cyanide plant, treating ores in the Zacatecas district, Mexico, which combines a number of Dorr thickeners with a vacuum filter in such a way that only pulp of low value in dissolved metal reaches the filter. This is necessary because the slime pulp is so extremely clayey that practically no washing can be accomplished in the filter, and the removal of the richer solution from the slime is essential before this reaches the filter. The Arbuckle pulp thickener[7] consists of a cone-shaped vat for the settlement of the slime, which is continuously removed from the apex of the cone by a screw conveyor in a tube fitted as a rising leg to the bottom of the cone. An overload alarm for the Dorr thickener is in use at the mill of the Blue Flag Gold Min. Co. at Cripple Creek.[8]

R. Gahl[9] has patented three systems of continuous decantation which involve no new principle. D. L. H. Forbes[10] describes experiments in the settling of mill slimes. He states that the following conditions govern the rate of settling slime in still water: (1) The size and shape of the slime particle; (2) the percentage of colloids present; (3) the dilution of the pulp; (4) the height of the column of pulp in which settling takes place irrespective of the size or shape of the cross-section; (5) the average specific gravity of the slime particles; (6) the presence of and the amount of electrolytes in the water. The fourth statement is not correct, for the settlement of dilute slime is independent of the depth of slime column as will appear below.

R. T. Mishler[11] discusses in an able way the question of settling slime. From his experimental work he concludes that the settling of dilute slime is independent of the depth of the slime pulp, that is the *rate* at which clear solution, and conversely thickened slime is formed, is not dependent on the depth, but is practically constant for all reasonable depths. What determines settling capacity primarily is the *area* available. Settling capacity is best expressed in pounds of thickened pulp, per square foot

[1] *Min. and Eng. World*, XXXVI, 1154.
[2] *Eng. and Min. Journ.*, XCIII, 1038.
[3] *Eng. and Min. Journ.*, XCIV, 301.
[4] *Eng. and Min. Journ.*, XCIV, 207.
[5] *Min. and Sci. Press*, CIV, 477.
[6] *Min. and Eng. World*, XXXVI, 607.
[7] *Min. and Eng. World*, XXXVI, 1268.
[8] *Eng. and Min. Journ.*, XCIV, 1123.
[9] *Eng. and Min. Journ.*, XCIII, 1046.
[10] *Eng. and Min. Journ.*, XCIII, 411.
[11] *Eng. and Min. Journ.*, XCIV, 643.

of settling surface, per hour. The amount of clear solution formed may be expressed in the same way. In this connection it is of interest to note that small scale experimental work is probably perfectly reliable for determining settling *rates* on a given slime, and that the necessary settling areas for plant design may be calculated from it. Mr. Mishler's results were criticised by C. H. Jakin[1] who cites his own experimental data to show the fallibility of small scale experimental work, but unwittingly proves that his experimental data is fully borne out by his large scale work, his difficulty being in not correctly interpreting his experimental work. The *rate* of settling is practically identical for the experimental and the large scale work as is shown by C. D. Demond,[2] whose figures were carefully checked by the present writer. Mishler's data may therefore be considered confirmed. For thick slime the settling rate is influenced by the depth of column, increasing with the depth until a critical thickness of pulp is reached. The following formula may be used to calculate settling capacity.

$$A = \frac{0.0222F\,(R_1 - R_2)}{S}$$

$S$ = rate of settling expressed in terms of depth in feet of clear solution formed per minute.

$F$ = feed of dry slime in tons per 24 hours.

$A$ = settling area in square feet.

$R_1$ = ratio of solution to solids in the feed. Thus: $\frac{6}{1} = 6$.

$R_2$ = ratio of solution to solids in discharge.

The value of $S$ is determined experimentally, in glass cylinders about 2.3 ft. high and 0.1 ft. in diameter, for slime at the dilution ($R_1$). The possible thickening or concentration of the slime or $R_2$ should also be determined by experiment. Mr. Mishler's article gives further interesting detail, for which reference should be made to the original paper.

H. B. Lowden[3] gives a valuable slime density table which is applicable over a considerable range of dilution as well as for a number of pulps of different gravities. R. S. Browne in the *Trans. Am. Met. Soc.*[4] gives formulas for calculating the recovery of dissolved gold and silver from slime.

L. C. Trent[5] describes a centrifugal machine for separating slime from coarser material, applicable however more to the recovery of heavy

[1] *Eng. and Min. Journ.*, XCIV, 872.
[2] *Eng. and Min. Journ.*, XCIV, 970.
[3] *Met. and Chem. Eng.* X, 369.
[4] *Min. and Eng. World*, XXXVII, 203.
[5] *Eng. and Min. Journ.*, XCIII, 1259.

base metal slime such as sulphides, than to that common in cyanidation. W. J. Nicol[1] describes the treatment of low-grade slime from present milling operations and from old dumps at the Lord Nelson mine, St. Arnand, Victoria. The slime is mixed with solution in a vortex mixer, and then passes to mechanical arm agitators, and thence to a Butters type of filter.

C. K. Barnes and A. A. Holland[2] have patented continuous revolving vacuum filters. B. W. Traylor has patented a continuous vacuum filter consisting of a chain of filtering plans travelling around sprocket wheels. The filter operates in a tank.

John E. Rothwell[3] has obtained a patent on a horizontal continuous vacuum filter. L. Cohen and John Gross[4] have invented a leaching device for sand which consists of an annular filter bed within a tank. The sand on the bed may be subjected to alternate leaching assisted by vacuum and aeration. The solution is sprayed on by a revolving distributor. When extraction is complete the sand is removed by sluicing. The Caldecott sand filter table is finding increased application on the Rand.[5]

E. J. Sweetland[6] describes the new Sweetland pressure filter which in general principles is the same as the Kelly or Burt filter. The filter comprises a series of frames resting upon a pair of side bars, and end or head pieces which form a closure for each end. Each frame carries an inserted gasket of rubber or other suitable material, and the frames are clamped together to form a water-tight chamber, by means of a heavy screw bearing against the movable head. Each frame carries a removable leaf and in the usual construction a space is left between the bottom of the leaf and the lower wall of the frame. The operation is as follows: The pulp to be filtered is admitted to the chamber at the bottom, air escaping by a valve at the top. When this valve is closed filtration begins, and when a cake of suitable thickness has formed, a vacuum is applied to the interior of the leaf, and the excess of pulp is withdrawn from the chamber. The formed cake may then be washed with water. For discharging the press, compressed air is turned into the interior of the leaves, while water under pressure is turned into the chamber to sluice out the cakes as they fall from the leaves. The press probably offers advantages for clarifying solutions preliminary to precipitation.

The same author[7] describes the Sweetland "clam-shell" filter. This consists essentially of a cylindrical steel sheel, closed at the ends, but

[1] *Min. and Eng. World*, XXXVII, 189.
[2] *Min. and Eng. World*, XXXVI, 1056.
[3] *Min. and Eng. World*, XXXVII, 535.
[4] *Met. and Chem. Eng.*, X, 374.
[5] *Eng. and Min. Journ.*, XCIV, 15, and MINERAL INDUSTRY, XVIII, 353.
[6] *Met. and Chem. Eng.*, X, 114.
[7] *Met. and Chem. Eng.*, X, 493.

split and hinged longitudinally so that it can readily be opened by dropping the lower part of the shell. Within the shell are a number of filter leaves connected to a vacuum. It is intended for discharging the filtered material as dry as possible. The Kelly filter press is receiving increased use, having been installed at a considerable number of plants in the last few years in the United States, Canada, and Mexico.[1] The filter consists of a number of vertical leaves attached to a movable carriage that runs in and out of an inclined steel cylinder. The movable head of the cylinder is made to seal the lower end hermetically when the carriage is run in for the filtering operation. When the carriage is run out with the cakes on the leaves, clear water and compressed air are forced from the inside of the leaves outward throwing off the cakes into a steel trough at the bottom of which a screw conveyor breaks up the cake and forwards it to the discharge launder. Final cleaning of the leaves is done by hose with high-pressure water. The slime cakes on the leaves as these are run out of the press contain 24 to 28 per cent. moisture at El Tigre, Mexico, and 15 to 18 per cent. at Parral, Mexico. The cylinders are 5×15 ft. and contain 13 leaves, with a total filtering area of 1300 ft. The framework of the leaves is made of pipe. The operating cycle is as follows:

| | At Parral, 8 Presses. | At El Tigre, 5 Presses. |
|---|---|---|
| Charging and building cake | 13 to 28 min. | 24 min. |
| Expelling surplus pulp | 2 | 6 |
| Washing with solution and water | 13 | 40 |
| Drying with air | 3 | 5 |
| Discharging cake | 10 | 40 to 60 |
| Total cycle | 40 to 50 | 115 to 135 |

At Parral the thickness of cake is 0.625 to 1 in. and at El Tigre about the same. The filter is suitable for colloidal slimes and affords a means of thorough washing. Its operating costs are somewhat high.

D. J. Kelly[2] has invented a device to indicate the thickness of the filter cake formed on the frame of the enclosed type of slime filter like the Kelly or Burt. The Bristol recording vacuum gage[3] is used at the Montana-Tonopah mill to automatically record the operation of the Butters' filters.

H. G. Smith[4] describes a variation from the ordinary method of operating a Butters' filter, with the idea of preventing the cracking of the slime cake during the transfer of the excess pulp. C. J. Stone[5] describes a leaf filter which operates without suction or pressure, but depends

[1] *Trans. A. I. M. E., Bul.*, 68, 797, and *Min. and Sci. Press*, CV, 4, 40.
[2] *Met. and Chem. Eng.*, X, 374.
[3] *Min. and Sci. Press*, CV, 766.
[4] *Min. and Sci. Press*, CV, 501.
[5] *Eng. and Min. Journ.*, XCIII, 368.

upon gravity to force the solution to the interior of the leaf. It seems a device of questionable merit. The operation of setting up and winding an Oliver filter[1] is described by H. B. Kaeding. The filter frame of a vacuum filter used at the Talisman mine, Karangahake, N. Z., is described by A. Jarman.[2] C. H. Fox[3] describes a device used in the acid washing of filter leaves at the West End Mill, Tonopah. The Moore filter Co.[4] proposes the use of lactic acid to remove lime incrustations from filter leaves. Lactic acid is non-volatile and non-corrosive and costs slightly more than hydrochloric acid, but may be shipped in barrels at ordinary freight rates, so that the cost at the plant is less than that of hydrochloric acid. A 10 per cent. solution at 150° F. gives good results as a solvent for the lime salts. The spent acid may be regenerated by installing suitable apparatus. If sulphur dioxide gas be passed through the spent solution, lime hypo-sulphite will be precipitated and lactic acid be regenerated. The method was used at the Ajax-Colburn mill at Victor, Col.

### Treatment of Concentrate

The question of concentrate treatment is receiving increasing attention. So far the direct treatment of concentrate by cyanidation is practically confined to gold mills. For silver milling, the problem is a much more difficult and complicated one.

E. M. Hamilton[5] discusses the question in an interesting and valuable article. In dealing with concentrate there are four possible courses open to the metallurgist: (1) The concentrate may not be separated but treated as part of the mill pulp; (2) it may be separated, ground to a required fineness and returned to the mill pulp; (3) it may be removed, and treated apart from the mill pulp by cyanidation; (4) it may be removed and shipped to a smelter. Which method is pursued depends entirely on the conditions obtaining in each case, and no general principles can be laid down. Each ore presents its own problems. It is, however, true that when the concentrate consists largely of lead and zinc sulphides, or contains considerable copper, or consists of manganese oxides in association with refractory silver minerals, cyanidation cannot be considered applicable, and the separation of the concentrate and shipment to a smelter must be resorted to. Data is given for four mills showing the relative costs of (1) concentrating and shipping concentrate, (2) concentrating and cyaniding concentrate, (3) not concentrating, but treating the pulp as a whole by cyanidation. The results at the several mills

[1] *Eng. and Min. Journ.*, XCIV, 639.
[2] *Min. and Eng. World*, XXXVI, 303.
[3] *Eng. and Min. Journ.*, XCIII, 639.
[4] *Met. and Chem. Eng.*, X, 249.
[5] *Eng. and Min. Journ*, XCIII, 839.

differ widely, as is to be expected, and leads to the conclusion that every mine presents a distinct problem. Some general statements, however, may be made concerning the treatment of concentrate by cyanidation. In most instances, one of the main items in the cost of treatment is the consumption of cyanide. In the cases given this is 20, 54, and 90 lb. respectively, ranging in cost from $3.60 to $15.75 per ton concentrate treated. Usually the chief source of cyanide consumption in the absence of copper or iron salts lies in the solution of the silver minerals; thus, 1 oz. of silver dissolved requires 0.082 lb. KCN. It is proposed to regenerate this cyanide by precipitating the silver from the solution by $Na_2S$. In an experiment the consumption of cyanide was 53 lb. per ton concentrate. By precipitating the silver from the solution by $Na_2S$, 38 lb. KCN (per ton concentrate) was regenerated. In the case of a concentrate containing copper minerals the consumption of KCN was 90 lb. per ton of concentrate. The solution from the treatment contained Cu, 0.1 per cent.; sulpho-cyanate (in terms of KCNS) 0.155 per cent.; and ferrocyanide, trace. The amount of KCN combined with Ag, calculated from the heads assay was 31 lb.; with the KCNS, 12.5 lb.; and with the copper, 38.7 lb. per ton of concentrate. In this instance the regeneration by $Na_2S$ would not show results as good as the first case, since the only cyanide regenerated is that combined with the silver.

The treatment of concentrate would be carried out as follows: (1) Treatment of concentrate with fresh solution in either small Pachuca, or mechanical agitation tanks. (2) Filtration and washing in a special horizontal vacuum filter. (3) Precipitation of the solution by $Na_2S$, in a storage tank provided with a mechanical agitator. The alkaline sulphide is added until lead salts show a brown coloration due to the first appearance of soluble sulphides in excess; 0.5 lb. commerical $Na_2S$ regenerates 1 lb. KCN from $KAg(CN)_2$. Precipitation of the silver is not quite complete. (4) The precipitate and solution are pumped through the clean-up press, where the precipitate is washed. (5) The solution is then precipitated the second time by zinc, for the recovery of the gold, and remaining silver, then passed to the general mill solution storage for its cyanide content. (6) The silver sulphide precipitate is reduced and melted to bullion. Concentrate which causes cyanide consumption on account of iron salts present should first be treated with lime water and thoroughly agitated to convert the iron into ferric hydrate, before cyanide solution is added.

R. Linton[1] and Noel Cunningham[2] discuss the cyanidation of concentrate high in silver. Both state that the cyanide consumption is

[1] *Journ. Chem. Met. and Min. Soc. South Africa*, July 1912; *Min. and Sci., Press* CV, 437.
[2] *Min. and Sci. Press*, CV. 634.

high. During agitation the protective alkalinity of the solution increases progressively due probably to the following reactions:

1. $Ag_2S+4\ KCN=2KAg(CN)_2+K_2S$.
2. $FeS+6KCN=K_4Fe(CN)_6+K_2S$.
3. $K_2S+KCN+H_2O+O=KCNS+2KOH$.

The great part of the cyanide consumption is due to the formation of KCNS and its attendant KOH, and it was found that lead salts did not prevent this. From the foregoing it would appear that reaction 3 is an unavoidable reaction in the cyanidation of silver sulphide, but this is not fully in accord with the data given by Hamilton, who seems to conclude that only part of the $K_2S$ formed by the dissolution of the $Ag_2S$ is converted to KCNS.

G. A. Denny and A. W. Allen[1] discuss the question of concentration-cyanidation or all cyanidation of silver ores. F. B. Reece[2] describes the cyanidation of an ore containing 20 to 25 per cent. of sulphides chiefly pyrite and dwells on the difficulties that arise in agitating this heavy pulp with the ordinary air-lift agitator. He also comments on the unsuitability of the leaf vacuum filter for pulp of this type.

A. E. Drucker[3] describes the treatment of concentrate at the properties of the Oriental Consolidated Mining Co., Unsan, Korea. A number of mills treat the ores by amalgamation, and concentration on Wilfley tables, vanners and canvas tables. The concentrate is cyanided. In addition, old concentrate dumps from a previous cyanidation are being retreated. This old dump material is reconcentrated on Wilfley tables, agitated in Pachuca tanks with lime water and then is reground in tube mills in 0.25 per cent. KCN solution. The tube mill product is classified, the coarse returned to the mill while the overflow is thickened to 1 to 1 dilution in Callow cones and passes to 10×40 ft. Pachuca tanks for continuous agitation. Additional cyanide is added at the Pachuca tanks. The pulp from the agitator tanks is filtered in Dehne filter presses. Precipitation is carried out by means of zinc dust. The method employed is similar to that used at the Alaska-Treadwell Mills.

## Chemistry of Cyanidation

L. Cohen[4] describes a number of experiments in cyanidation, dealing with aeration, addition of picric acid, etc. H. A. Megraw[5] discusses in an interesting manner the questions of cyaniding troubles and their remedies. The article refers to both mechanical and chemical diffi-

[1] *Min. Mag.* VI. 117, 293 and VII, 44.
[2] *Min. and Sci. Press*, CV., 77.
[3] *Min. and Sci. Press*, CIV, 103; CV, 652.
[4] *Met. and Chem. Eng.*, X, 203.
[5] *Eng. and Min. Journ.*, XCIV, 311, 360.

culties. Ya Mikhailenko and M. I. Meshcheryakov[1] give the effect of oxidizing agents on the solubility of gold in KCN solution saturated with air. Hydrogen ions diminish velocity of solution, an excess arresting the reaction. Hydroxl ions do not accelerate solution and in excess retard it. In solutions with no excess alkali, the following substances have no effect on the velocity of reaction: quinone, $Na_2SnO_3.3H_2O$, $KBrO_3$, $KIO_3$, $KClO_3$, $Hg(CN)_2$, $CuCl_2$. The following salts accelerate solution: $KClO_4$, $KMnO_4$, $NH_4SO_4$, $Na_2O_2$, $K_2SO_4$, $Na_2SO_4$, Br, $K_3Fe(CN)_6$, and $K_2CO_3$. The effect of these substances increases with their concentration up to a certain limit, above which their effect is to retard solution.

J. E. Clennell[2] discusses the effect of adding lead salts in cyanide treatment. These are added on the assumption that alkaline sulphides are removed with the precipitation of insoluble lead sulphide. The alkaline sulphides are in part a product of the dissolution of silver sulphide by an alkaline cyanide. Alkaline sulphides, however, exist only momentarily in the solution, for it is probable that they are converted into thiocyanates with a consumption of cyanide, and also precipitated by the $K_2Zn(CN)_4$ in the solution. Under certain conditions where there is a tendency to form considerable alkaline sulphides, lead salts are beneficial. It is found that any lead salt, soluble or insoluble will do, except lead tartrate. Even finely ground galena will answer. It was found that a certain amount of lead salt, varying with the ore and the compound used (from 0.8 to 2.4 Kg. PbO and $Pb(C_2H_3O_2)_2$ per ton ore) gave the best results. Amounts less or greater gave reduced extractions. Lead salts also gave beneficial results in the case of copper in the solution. Lead acetate and litharge are quite soluble in working cyanide solutions and when added in large amounts accumulate in the solution to be precipitated later on the zinc. In the case of a soluble salt like acetate, the acid radicle may accumulate in solution as potassium acetate and break down into such substances as formic acid and formates which exert a reducing effect on silver salts in solution. When no lead salts are used free sulphur is sometimes found suspended in solution, and affects extraction. The chemistry involved in the effect of lead salts on cyanidation is still unsolved. It is difficult to see for instance what the beneficial result of adding finely ground galena can be, except that perhaps it is dissolved by cyanide, acting as in the following reactions,[3] which are cyclic.

$$PbS+KCN+O=PbO+KCNS$$
$$PbO+2KOH=K_2PbO_2+H_2O$$
$$K_2PbO_2+K_2S+2H_2O=PbS+4KOH.$$

[1] *Min. and Sci. Press*, CV, 500, from *Journ. Russ. Phys. Chem. Soc.*, XLIV 567.
[2] *Eng. and Min. Journ.*, XCIV, 597 and 921.
[3] MINERAL INDUSTRY, XVII, 456.

This involves the removal of sulphides as thiocyanates and a consumption of cyanide. A critical discussion of the reactions involved in cyaniding silver ores, including the above question is given by E. Kühn.[1] This paper goes into the question very thoroughly in some respects and contains so great a mass of valuable detail that the available space does not permit of abstracting it satisfactorily.

A. F. Crosse[2] discusses the effect of sulphate of magnesia (kieserite) and of ferric arsenate (scorodite) on cyanide solutions. These minerals sometimes occur in ores and are a source of cyanide consumption. He states that magnesium sulphate cannot very well be neutralized by lime as the $CaSO_4$ formed decomposes cyanide. This is not in accordance with the opinion of many cyanide chemists. $Na_2CO_3$ is proposed as a more successful neutralizing agent giving rise to $Mg(OH)_2$ and $Na_2SO_4$. Finely ground scorodite dissolves slowly in cyanide solution forming sodium arsenate. This latter is the cause of the arsenic deposition in the zinc boxes. It is proposed to add Na(OH) to the cyanide solutions to dissolve whatever amount of scorodite goes into solution, thus protecting cyanide, and then precipitate the arsenic by the addition of lime, in the form of calcium arsenate.

A. McA. Johnston,[3] and W. H. Coghill[4] discuss the question of iron in mill pulp. Metallic iron in a finely divided condition destroys alkaline cyanides with the formation of potassium or sodium ferro-cyanide. The metallic iron is derived from pieces accidentally mixed with the ore during mining and coarse crushing, from the wear of iron crushing parts in the batteries and from screens. In the present system of milling on the Rand, the coarser particles of iron collect in the tube mill circuit, and stay in the circuit until crushed fine enough to pass out of it. In the circuit it tends to interfere with amalgamation on the plates due to its high specific gravity and when it finally passes to the cyanide plant it is the cause of a small but persistent cyanide consumption. At one of the mills of the Consolidated Gold Fields a magnetic separator was installed ahead of the tube mill circuit and at present about 400 to 600 lb. of iron admixed with some quartz and pyrite are recovered daily from 2500 tons of ore. This material is permitted to thoroughly weather in heaps being wetted and turned over every day, and when fully oxidized is fed to the batteries. Tests on the oxidized material containing about $6 per ton gave an extraction of 72 per cent. by amalgamation and cyanidation.

E. H. Webster[5] discusses the use of sodium sulphide as a precipitant

[1] *Metallurgie*, VIII, 399, 421, 457 and 481.
[2] *Min. and Sci. Press*, CV, 16, from *Journ. Chem., Met. and Min. Soc., South Africa.*
[3] *Journ. Chem., Met, and Min. Soc., South Africa*, Aug. 17, 1912, and *Min. and Sci. Press*, CV, 463.
[4] *Min. and Sci. Press* CIV, 413.
[5] *Eng. and Min. Journ.*, XCIII, 973.

for silver in cyanide solutions which question has already been referred to. W. H. Coghill[1] describes experiments on refractory manganese silver ores from Arizona and from Durango and Jalisco, Mexico. He tried many methods on these ores including, thiosulphate leaching, cyanidation, amalgamation and others with negative results. The silver is associated in some way with the manganese but in what manner could not be determined It was found that if the finely ground ore was first treated with sulphurous acid to dissolve manganese and then neutralized that the silver was dissolved by cyanide solution with great rapidity.

J. R. Parks[2] describes an electro-cyanide process. It embodies the old idea of recovering the precious metals by cyanidation in one operation, as amalgam, by employing a 15-ft. treatment vat which contains in the bottom an amalgamated copper plate connected to the negative pole of an electric circuit. In the Parks' plan the anodes are two annular iron rings, provided with radial paddles, revolving 2 in. above the copper plate. The revolving anodes serve as the agitator device. Salt is added to the solution, aside from the cyanide, to increase the conductivity of the solution, and to form sodium hydrate to neutralize acidity in the ore. The current used in a standard 15-ft. pan (7.5 ton charge) is 400 amperes, with a drop of potential of 9 to 10 volts. Cyanide is regenerated. After the treatment of about 6 hours the pulp is run through s settler and thence to a Dorr thickener for the recovery of solution which is used again in the pan.

H. R. Edmands[3] describes the treatment of weathered pyritic tailings from the Lady Gladys Co. at Mulline W. A. The tailings contained considerable amounts of marcasite, arsenopyrite, blende and their decomposition products. The soluble acidity was equivalent to 12.2 lb. CaO, and the total acidity to 35.2 lb. CaO per ton. $FeSO_4$ was present to the extent of 3.3 lb. per ton. A preliminary wash was found to offer no advantages, rather the contrary. The method finally adopted was to mix 50 lb. of slacked lime per ton intimately with the ore, pass the mixture over 0.5-in. screens and charge into the leaching vats. Water or barren solution was then passed through the charge the solution usually coming off slightly alkaline. Repeated washings with complete draining between them were applied to oxidize the ferrous hydrate to the ferric form. Then a 40-day treatment with 0.05 per cent. KCN solution was given, the total amount of solution used being 6 tons per ton of sand. The tanks held 400 tons sand and 50 to 80 tons of thoroughly rated solution were pumped on the charge daily. The tailings con- ned $11 in gold per ton, and the residues from the treatment $1.33

, and *Sci. Press*, CIV, 754, 794.
ol of *Mines Quart.*, XXXIII, 365, and *Eng. and Min. Journ.*, XCIV, 263.
, and *Min. Journ.*, XCIII, 605.

per ton. The consumption of cyanide was 4 lb. KCN, per ton. In experimenting to discover a satisfactory method of treatment, NaOH was first used to neutralize acidity. It was found that the consumption of alkali was much in excess of that indicated by the acidity tests, due to the solvent effect of the alkali on the sulphides in the presence of oxygen. The solutions contained much thiosulphate but practically no alkaline sulphides. Sodium hyposulphite was also present in the solution, the color of which was brown. This solution was as effective in dissolving gold as fresh solution if it was first thoroughly aerated, but on passing it successively through a number of charges its solvent effect rapidly decreased. It could, however, be resorted by passing it through the zinc boxes. This would point to the removal of reducing agents. With the use of lime the oxidation of the sulphides is not pronounced, and on the whole its use is much to be preferred to that of sodium hydrate. If soda must be used the carbonate is better than the hydrate.

P. L. Guppy and D. Waterman[1] give methods for the determination of base metals in cyanide solutions. W. H. Coghill[2] describes experiments to determine the effect of copper minerals in an ore on the extraction of the silver. W. Bettel[3] describes the treatment method of old dump slime in which potassium premanganate is used to oxidize ferrous sulphate to the ferric form, before cyaniding. B. G. Nicholl[4] and W. D. Williamson[5] discuss the regeneration of cyanide solutions containing copper, based on Wheelock's method already refered to in previous volumes of the MINERAL INDUSTRY.[6]

### PRECIPITATION AND TREATMENT OF PRECIPITATES

Chester Steinem[7] proposes to clarify cyanide solutions previous to precipitation by the addition of small amounts of potassium alum. The addition of this salt to cyanide solution caused the formation of a copious precipitate and an odor of hydrocyanic acid, but it is stated that cyanide was slightly regenerated. This is hardly creditable for solution containing free cyanide since aluminium sulphate will destroy the alkaline cyanides. Other difficulties would undoubtedly arise also.

F. H. Wetherald[8] describes an interesting filter for clarifying cyanide solutions preliminary to precipitation. It consists of a number of canvas filter frames in construction similar to the leaf of a vacuum filter. No

[1] *Min. and Sci. Press*, CV, 597.
[2] *Min. and Sci. Press*, CV, 203.
[3] *Min. and Eng. World*, XXXVI, 910.
[4] *Min. and Sci. Press*, CIV, 406, 506.
[5] *Min. and Sci. Press*, CV, 49.
[6] MINERAL INDUSTRY, XVIII, 358.
[7] *Eng. and Min. Journ.*, XCIII, 739.
[8] *Eng. and Min. Journ.*, XCIV, 884.

vacuum, however, is used, but the solution percolates through the filter frames by gravity. The frames are placed about a foot apart to permit of cleaning them by means of a brush.

D. Bosqui[1] has obtained a patent for apparatus to precipitate gold and silver from cyanide solution by means of zinc dust. It consists of two tanks, provided with Trent agitators. The tanks are alternately filled and emptied, and the zinc dust addition to the tank in which the solution is to be precipitated is controlled by an automatic device operated by floats whose action is determined by the level of the solution in the tanks. The agitators assure a thorough mixing of zinc dust and solution. The floats also control the discharge from the tanks. When one tank is filled to a certain level the action of the float transfers all the incoming solution to the second tank while opening the discharge valve of the first tank, sending the precipitate and solution to the filter presses.

R. K. Cowles[2] discusses the reprecipitation of gold and silver by carbon and the consequent low extraction in treating tailings containing coal ashes. He states that the extraction of gold is more influenced than that of silver. W. H. Davis[3] has patented an electrolytic cell for precipitating gold and silver from solution with rotating vertical cathodes disposed transversely to the flow of solution. The cathodes are of wire screen, and the anodes are vertical bars suspended near the cathodes. The nature of the anode and cathode material is not mentioned.

B. G. Nicholl[4] describes a new electrolytic precipitation process for gold and silver from cyanide solution in use at the Mitchell's Creek Gold Rec. Co., Bodangora, N. S. W. The anodes are rods of Acheson graphite. 0.5×24 in., placed side by side to form a plate, and the cathodes consist of corrugated water-proofed felt or cardboard which has been made superficially electrically conductive by treatment with an adhesive compound and Acheson graphite powder. The cathode surface is 5000 sq. ft. which is sufficient to precipitate 200 tons per 24 hours. The current density is 0.5 ampere per square foot. In precipitating such solutions as occur in cyanidation great cathode area is necessary. The distance between anode and cathode is 0.375 in. The cathode must be sufficiently strong to prevent warping. This is done by passing a wire around the sides and bottom, the ends of the wire being bent over so as to dip into the mercury grooves for electrical contact. A 0.5-in. layer of kerosene is kept on top of the solution in the precipitation box to prevent frothing and the escape of HCN. The regeneration of cyanide in this

[1] *Min. and Eng. World*, XXXVI, 1255
[2] *Min. and Sci. Press*, CV, 730.
[3] *Met. and Chem. Eng.* X, 489.
[4] *Min. and Sci. Press*, CIV, 407.

method is from 0.5 to 2 lb. per ton of solution. W. J. Sharwood[1] describes tests of zinc dust for precipitation purposes. The dust should be dry and fine; 95 per cent. should pass a 200-mesh screen; not over 2 per cent. should remain on a 100-mesh. It should not show signs of caking nor contain lumps. Generally speaking an ash gray color is most desirable. The presence of 2 to 3 per cent. Pb is of advantage. The presence of a small amount of zinc oxide is not detrimental. The specific gravity varies from 6.28 to 7.00, and the dust weighs from 2 to 2.5 grm. per cubic centimeter or 120 to 155 lb. per cubic foot depending upon the extent to which it has been shaken down. It must be kept from contact with moisture or moist air.

Table III gives analysis of various zinc dusts.

TABLE III.—COMPOSITION OF ZINC DUST.

| Source. | Metallic Zinc, Per Cent. | Zinc oxide, Per Cent. | Lead. | Iron, Cadmium, Carbon, and Insoluble. |
|---|---|---|---|---|
| 1. Belgian | 91.50 | little | 0.50 | ..... |
| 2. Belgian | 88.74 | 6.60 | 2.50 | 2.1 |
| 3. Belgian | 79.16 | 11.26 | 1.90 | 7.2 |
| 4. Belgian (average) | 84.50 | 9.30 | 1.60 | 4.0 |
| 5. Silesian | 84.50 | 4.90 | 4.30 | 6.2 |
| 6. Silesian | 88.50 | 7.40 | 2.00 | 3.00 ($SO_3$=4.1) |
| 7. Silesian | ..... | 88.20 | 4.00 | insol. 9.6 |
| 8. American | 29.60 | 57.50 | trace | ..... |
| 9. American (good) | 96.00 | ..... | ..... | ..... |
| 10. European (good) | 90.90 | 4.00 | 2.70 | ..... |
| 11. European (fair) | 85.00 | ..... | 2.00 | ..... |
| 12. European (fair) | 94.60 | 3.70 | 0.20 | iron 0.3 |
| 13. Used at Deloro, Can. | ..... | 3 to 5 | 1.74 | ..... |

The article gives methods for testing dust as to precipitation efficiency, analysis for lead, zinc oxide and metallic zinc, and the mechanical test as to fineness.

In cutting zinc shavings on a lathe it is desirable to wind them as a skein as is done at the Liberty Bell mine in Colorado.[2] Atomized zinc or a mixture of atomized zinc and lead made by a new atomizing process is advocated for use in precipitating gold and silver from cyanide solutions.[3] Aluminium dust is used as a precipitant at the O'Brien mine at Cobalt, Canada, and also at Nipissing Mills.

H. W. Hixon[4] proposes a method of smelting zinc-gold-silver precipitates by means of a blast furnace and cupelling furnace with a bag-house adjunct. This type of method has been in use at the Homestake mine for many years,[5] and has been described in a previous volume of

[1] *Min. and Sci. Press*, CIV, 659; *Eng. and Min. Journ.*, XCIII, 943; *Journ. Chem., Met. and Min. Soc., South Africa*, Feb., 1912.
[2] *Eng. and Min. Journ.*, XCIV, 1170.
[3] *Met. and Chem. Eng.*, X, 180, 302.
[4] *Eng. and Min. Journ.*, XCIV, 1027.
[5] MINERAL INDUSTRY, XVI, 551.

the MINERAL INDUSTRY. It is given in much detail in a recent paper by A. J. Clark and W. J. Sharwood.[1] C. J. Brooks[2] describes the cupellation of gold precipitate at Bau, Borneo. The precipitate obtained by zinc shavings contains in part a considerable percentage of calcium carbonate, due to the high lime content of the solution. Part of the precipitate from the slimes plant contains also a high percentage of clay. That part of the product high in lime carbonate is placed in the acid treatment vat, and water added. Then hydrochloric acid is added in small quantities at intervals. When the lime is in solution the precipitate is allowed to settle, the solution is decanted and pumped through the press, and the precipitate washed four times with water by decantation. Treatment with sulphuric acid is then applied in the usual way, to all of the precipitate. The acid treated precipitate is then pumped to the press and washed until all soluble sulphates are out. It is then steamed and dried and smelted in Faber du Faur furnaces, with from 15 to 70 per cent. of its weight in flux consisting of borax, sand and sodium carbonate. The product of the fusion is bullion, 800 to 900 fine in gold and silver; a small amount of matte, containing gold, about 6.88 per cent. and silver, 27. 61 per cent., and slag. The slag and matte are ground and mixed with 15 per cent. PbO and sufficient carbon to reduce the lead. It is then fused and at the end of the fusion a few pounds of fine iron are introduced, to precipitate lead from the matte which may be present in small quantity. The slag from this fusion is ground and concentrated on a Wilfley table for the recovery of metallics. The lead bullion and the original gold-silver bullion are then cupelled in a small portable cupelling furnace fired with an oil burner. The test ring is 1 ft. 9 in. in diameter and the test is made of a mixture containing 75 lb. Portland cement, 10 lb. fire clay, and 12 lb. crushed fire-brick, ground to pass a 40-mesh screen. The test holds 50 lb. bullion. In a day's run of 12 hours, 320 lb. of lead and gold bullion are refined. The resultant bullion is of 953 fineness (685 gold and 268 silver). The litharge from the cupellation is used over again in the next month's run. The analysis of precipitates from this property and others is given in the accompanying table.

*Note.*—*A*, *B* and *C* precipitates from gold ore, Bau, Borneo. *D* and *E* precipitate from strong and weak solution respectively, Silver ore, El Tigre, Mexico. *F*, weak solution; *G*, low solution; *H*, average precipitate; *I*, average precipitate after acid treatment, Homestake mine, S. D.

[1] *Trans. I. M. and Met., Bul.* 98, 1912.
[2] *Min. Mag.*, VI, 193.

COMPOSITION OF PRECIPITATES.

| Constituent. | A. | B. | C. | D. | E. | F. | G. | H. | I. |
|---|---|---|---|---|---|---|---|---|---|
| Silica and gangue | 17.66 | 2.82 | 38.00 | 4.80 | 4.30 | ..... | ..... | ..... | ..... |
| Iron | 3.32 | 0.76 | 3.12 | 0.82 | 0.91 | 0.38 | 0.10 | 0.37 | 0.40 |
| Alumina | 3.98 | 1.63 | 10.23 | 4.50 | 3.70 | ..... | ..... | ..... | ..... |
| Zinc | 24.92 | 35.01 | 12.66 | 6.38 | 8.90 | 37.60 | 53.30 | 44.00 | 19.90 |
| Lime | 6.69 | 9.17 | 5.32 | 2.12 | 2.16 | 6.72 | 6.72 | 6.12 | 6.44 |
| Magnesia | 0.17 | 0.39 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Alkalies | 2.27 | 4.00 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Insoluble | ..... | ..... | ..... | ..... | ..... | 1.27 | 0.88 | 0.95 | 1.81 |
| Gold | 8.044 | 19.629 | 9.00 | 0.31 | 0.20 | 13.20 | 1.65 | 9.50 | 16.55 |
| Silver | 2.276 | 5.424 | 5.45 | 61.96 | 41.82 | 4.45 | 0.78 | 3.34 | 5.83 |
| Copper | 2.47 | 2.82 | 1.61 | 10.60 | 23.00 | 0.35 | 0.85 | 0.70 | 0.70 |
| Lead | 4.80 | 7.86 | 3.28 | ..... | ..... | 9.85 | 11.40 | 9.45 | 16.70 |
| Tin | 0.10 | 0.18 | 0.62 | ..... | ..... | ..... | ..... | ..... | ..... |
| Antimony | 0.10 | 0.11 | 0.62 | ..... | ..... | ..... | ..... | ..... | ..... |
| | | | | | | | | | $SO_4$ |
| Arsenic | 1.68 | 1.67 | 0.42 | ..... | ..... | ..... | ..... | ..... | 19.82 |
| Sulphur | 0.62 | 0.87 | ..... | ..... | ..... | 9.51 | 2.96 | 6.38 | 6.35 |
| Selenium | 0.34 | 0.08 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | | | | | | $CO_2$ | $CO_2$ | $CO_2$ | |
| Carbonic acid | 10.28 | 6.29 | 10.29 | ..... | ..... | 7.20 | 7.70 | 7.23 | 0.0 |
| Moisture | 8.79 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Oxygen, loss | 1.59 | 1.25 | | | | | | | |
| Undetermined | ..... | ..... | ..... | 6.05 | 11.81 | ..... | ..... | ..... | ..... |
| Mercury | ..... | ..... | ..... | ..... | ..... | 0.05 | 0.02 | 0.095 | 0.10 |

M. W. von Bernewitz[1] describes a method of treating matte from precipitate smelting, by fusing it with 50 per cent. of its weight with a flux one-half borax and one-half cyanide. A button of bullion and some low-grade matte is the result. He also gives some results obtained by refining bullion with air as recommended by Rose.

H. R. Edmands[2] details experiments with the sulphur refining of bullion, and the treatment of the resultant matte by iron. W. E. Darrow[3] describes a method of refining precipitate by treating it with strong chlorine solution to dissolve most of the gold precipitating this with ferrous sulphate. The residue from the chlorine treament is then neutralized with caustic soda and treated with strong cyanide solution to dissolve gold and silver. This is then precipitated on zinc again, giving a clean silver precipitate. The gold precipitate from chlorination and the silver precipitate are then melted together into bullion about 960 fine.

D. F. Irvin[4] describes an electrically heated dryer for precipitate used at the El Tigre mine, Mexico. It consists of a series of sheet-iron trays enclosed in a ventilated sheet-iron cage. The heating coils are placed directly under the trays. No. 18 hard-drawn iron wire wound on asbestos is employed. Thirty to 35 amperes at 110 volts are used. The capacity of the dryer is 175 kg. precipitate in 24 hours.

H. R. Conklin[5] describes an electric furnace for smelting precipitate at the Lluvia de Oro Gold Min. Co. in Chihuahua, Mexico. The furnace

[1] *Min. and Sci. Press*, CIV, 343.
[2] *Min. and Sci. Press*, CV, 55.
[3] *Eng. and Min. Jour.*, XCIV, 785.
[4] *Min. and Sci. Press*, CIV, 405.
[5] *Eng. and Min. Journ.*, XCIII, 1189.

consists of a rectangular shaft of fire-brick, 16 in. square and 4 ft. deep, inside dimensions. It is a resistance furnace, relying on the resistance of the slag bath formed, for the heating effect. The electrodes are carbon rods, 4 in. in diameter and a 1×2.5 in. iron bar in the bottom of the furnace. The furnace is also used to smelt down rich concentrate.

F. P. Dewey[1] comments on the base metals present in cyanide bullion, having noted particularly cadmium and nickel as quite common constituents. H. A. White[2] discusses the retention of gold in a new mill and mentions particularly the bullion absorbed by the brickwork of furnaces smelting zinc-gold precipitate.

## AMALGAMATION[3]

There is considerable discussion among metallurgists as to the advisability of abandoning amalgamation when used with subsequent cyanidation for ores in the treatment of which amalgamation is now a prominent feature. It would seem to the writer that while no general principles can be stated as applicable to all ores, the general abandonment of amalgamation would be very unwise in most cases.

H. Stadler[4] states that in Rand practice a high extraction by amalgamation has a far-reaching effect on total extraction consequent on the lowering of gold content left in the final pulp for cyanide treatment where only 85 to 90 per cent. is recoverable under the best actual conditions. That is, total extraction is apt to be higher when the recovery by amalgamation is high, and while by prolonged cyanide treatment at increased cost the same total amount of gold may be recovered, this is best done by the simple and cheaper amalgamation method.

G. H. Stanley and M. T. Murray[5] investigated the subject of the absorption of gold by amalgamated plates. A plate 0.14 in. thick which had been in service for 14 years, and had been sweated and scraped but not scaled was used in the investigation. Successive layers 0.02 in. thick were taken for assay with the results indicated below.

| Layer. | Gold, Per Cent. | Mercury, Per Cent. | Lead, Per Cent. |
|---|---|---|---|
| 1 | 10.48 | 9.39 | 0.085 |
| 2 | 0.0166 | tr. | 0.084 |
| 3 | 0.00505 | tr. | 0.080 |
| 4 | 0.0084 | tr. | 0.053 |
| 5 | 0.0041 | tr. | 0.089 |
| 6 | 0.0145 | tr. | 0.089 |
| 7 | 0.0018 | 1.89 | 0.104 |

[1] *Eng. and Min. Journ.*, XCIII, 733.
[2] *Min. and Sci. Press*, CIV, 500.
[3] Amalgamation tables and devices are discussed in the article on Progress in Ore Dressing by Professors Richards and Locke.
[4] *Min. and Sci. Press*, CV, 78.
[5] *Journ. Chem., Met. and Min. Soc., South Africa*, Dec., 1911.

The plate was also amalgamated on the under side.

Over 99 per cent. of the gold was in the first layer and the balance was irregularly distributed. The little gold in the interior of the plate probably finds its way there by means of pores in the copper which intercommunicate. It seems, however, more probable that its presence is due to a slight but real diffusion action. However, the absorption may be considered as negligible from a commercial viewpoint.

A. J. Clark and W. J. Sharwood[1] reach practically identical conclusions for amalgamation practice at the Homestake Mine, S. D. It was found that in old mill plates 98 per cent. of the gold was in a layer 0.015 in. next to the surface. They give interesting and valuable data on amalgamation practice.

## Miscellaneous

A. H. Jones[2] gives data of the effect of heating cyanide solutions during agitation, at the Belmont mill, Tonopah. The effect of heated solutions seems to be greater on silver than on gold.

| Ore I, Gold = 0.05 oz.; Silver, 18.2 oz. | | | Ore II, Gold 0.05 oz.; Silver, 20.6 oz. | | |
|---|---|---|---|---|---|
| Time of Agitation. | Temp. | Value of Tailings. | Time of Agitation. | Temp. | Value of Tailings. |
| 60 hours..... | 60° | $1.86 | 48 hours..... | +90 | ..... |
| 60 hours..... | 90° | 1.06 | 48 hours..... | +90 | 1.61 |
| 60 hours..... | 60° | 2.32 | 48 hours..... | 60 | 2.67 |
| 60 hours..... | 90° | 1.36 | 69 hours..... | +90 | 1.06 |
| 60 hours..... | 64° | 2.12 | 69 hours..... | +90 | 1.36 |
| 60 hours..... | 87° | 1.49 | 69 hours..... | 60 | 2.32 |
| 60 hours..... | 109° | 1.06 | | | |

The cost of heating mill solutions for the past nine months has been 16.1 cents per ton of ore treated, thus showing the marked advantage for heating solutions.

Noel Cunningham[3] and M. W. von Bernewitz[4] confirm the statement that heating solutions is beneficial. At the Tonopah mills an increased saving of 24 to 32 cents is obtained at a cost of 11 cents. The last named author describes the roasting of gold ore at the Associated mine, Kalgoorlie.[5] Four Edwards' duplex furnaces each with 107×11.75 ft. hearths are in use. Each furnace uses 6.5 h.p. The rabbles make from 4 to 6 r.p.m. and each furnace has 52 rabbles. Each furnace roasts about 85 tons of ore daily, with a fuel consumption of 11 per cent. of the weight of the

[1] *Trans. Inst. Min. and Met. Bul.*, 98, 1912.
[2] *Min. and Sci. Press*, CIV, 176.
[3] *Min. and Sci. Press*, CIV, 315.
[4] *Min. and Sci. Press*, CV, 828.
[5] *Min. Mag.*, VI, 127.

ore roasted. Flue dust amounts to 0.5 per cent. and the cost of roasting is 58 cents per ton. There is no loss of gold by volatilization. The completeness of the roast is tested by taking the soda extract of a weighed quantity of ore and titrating for the amount of reducing agent with a N/100 iodine solution.[1] The report of the Esperanza Mining Co., El Oro, Mexico,[2] gives detailed figures on the consumption of mill supplies, such as cyanide, lead acetate, lime, etc.

T. P. Holt[3] gives interesting data on the ores of the Mercur mine, Utah. The base ores of this mine have been shown to contain carbon which causes a reprecipitation of gold during cyanide treatment. The carbon content ranges from 0.105 per cent. in oxidized ore to 0.450 per cent. in the base ore. The temperature of roasting affects the solubility of the gold. The best results are obtained when the maximum temperature does not exceed 650° C., when the extraction reaches 90 per cent. When the temperature reaches 1100° C., the extraction drops to less than 50 per cent. While the higher temperature more completely eliminates carbon, it causes a sintering of the ore which effectually locks up the gold. During 1911 the cost of roasting was 92 cents per ton. A device known as the Black Hills solution sampler and weigher is in use at the Hollinger mill,[4] Porcupine district, Ontario.

W. H. Todd[5] describes the device in use at the Homesake mills for the sampling of sands. James Spiers describes a solution meter for use in cyanide plants.[6] At theHomestake mine, S. D., a special calculator device is used to determine the amount of cyanide to be added to working solutions.[7]

Jesse Simmons[8] describes the methods of charging sand tanks by means of belt conveyors at the Wasp No. 2 mill, near Deadwood, S. D.

H. T. Durant[9] describes a pump suction device in connection with the pumping of pulp from tanks by centrifugal pumps. The painting of wooden cyanide tanks[10] is best done on the outside only, for if painted inside also they are less apt to stay tight, since the solution in the painted tank will penetrate the wood in spots and cause unequal swelling.

E. H. Webster[11] discusses cyanide mill metallurgical records in detail. A. W. Allen[12] describes a method of making leaching tests on sands.

[1] *Min. and Sci. Press*, CV, 300.
[2] *Eng. and Min. Journ.*, XCIV, 885.
[3] *Mines and Minerals*, XXXII, 355.
[4] *Eng. and Min. Journ.*, XCIV, 1169.
[5] *Eng. and Min. Journ.*, XCIII, 541.
[6] *Min. and Eng. World*, XXXVI, 1155.
[7] *Eng. and Min. Journ.*, XCIII, 691.
[8] *Eng. and Min. Journ.*, XCIV, 159.
[9] *Eng. and Min. Journ.*, XCIV, 159.
[10] *Eng. and Min Journ.*, XCIV, 351.
[11] *Eng. and Min. Journ.*, XCIII, 791, 970.
[12] *Min. and Sci. Press*, CIV, 282.

# GRAPHITE

The production of natural graphite during 1912 in the United States was 2445[1] short tons, a decrease of one-third from the production in 1911. As in recent years one-third of the production is amorphous graphite and graphitic shale. The crystalline graphite, generally obtained by milling in Alabama, New York and Pennsylvania, amounted to 3,543,771 lb., a decline from the 1911 production of 4,790,000 lb. While prices for this product have not suffered and demands were good, the competition from imported graphite, chiefly from Ceylon, has supplied the market. The chief factor is a standard quality of the foreign product; the Ceylon graphite is granular in structure and not thin as the flake graphite; the former is preferable for crucibles for this reason. While no import duty is paid the average value per pound as declared was lower in 1912 than in 1911. The use of this graphite is mostly for crucibles. Of the tonnage imported 70 per cent. is used for crucibles, 15 per cent. for foundry facings, and 10 per cent. for stove polish. Importations from Mexico, Chosen, Austria and Germany are chiefly amorphous graphite. The best from Mexico is used in lead pencils.

Artificial amorphous graphite, manufactured by the International Acheson Company at Niagara Falls, was produced in larger quantities and at a lower figure than before. In 1912 this product amounted to 12,896,347 lb. valued at $830,193. The production record of 1910 was not quite reached.

STATISTICS OF GRAPHITE IN THE UNITED STATES.

| Year. | Refined Crystalline Graphite. | | | | | | Amorphous Graphite Production. | | Artificial Graphite Production. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Production. | | Imports. | | Consumption (a). | | | | | |
| | Pounds. | Value. | Pounds. | Value. | Pounds. | Value. | Tons. 2000 lb. | Value. | Pounds. | Value. |
| 1899 | 3,632,608 | $145,304 | 41,586,000 | $1,990,649 | 45,218,608 | $2,135,953 | 1,030 | $ 8,240 | 405,870 | $ 32,475 |
| 1900 | 4,103,052 | 164,122 | 32,298,560 | 1,389,117 | 36,401,612 | 1,553,239 | 1,045 | 8,640 | 860,750 | 68,860 |
| 1901 | 3,967,612 | 135,914 | 32,029,760 | 895,010 | 36,997,372 | 1,067,921 | 809 | 31,800 | 2,500,000 | 119,000 |
| 1902 | 4,176,824 | 153,147 | 40,857,600 | 1,168,554 | 45,034,424 | 1,322,401 | 4,739 | 55,964 | 2,358,828 | 110,700 |
| 1903 | 4,525,700 | 164,247 | 32,012,000 | 1,207,700 | 36,537,700 | 1,371,947 | 16,591 | 71,384 | 2,620,000 | 178,670 |
| 1904 | 4,357,927 | 162,332 | 25,350,000 | 905,581 | 29,707,927 | 1,067,913 | 19,115 | 102,925 | 3,248,000 | 217,790 |
| 1905 | 4,260,656 | 170,426 | 34,914,611 | 983,034 | 39,175,267 | 1,153,460 | (b)21,953 | 80,639 | 4,595,500 | 313,979 |
| 1906 | 4,894,483 | 170,866 | 50,974,336 | 1,554,212 | 55,868,819 | 1,725,098 | (b)16,853 | (c) | 4,868,000 | 312,764 |
| 1907 | 4,586,149 | 149,548 | 40,962,000 | 1,777,389 | 45,548,149 | 1,926,937 | (b)26,962 | 138,381 | 6,924,000 | 483,717 |
| 1908 | 3,433,039 | 149,763 | 22,912,714 | 762,267 | 26,345,753 | 876,030 | (b) 1,433 | 75,250 | 7,385,511 | 502,667 |
| 1909 | 5,669,899 | 340,194 | 42,532,851 | 1,854,459 | 48,202,750 | 2,194,653 | (b) 5,096 | 32,238 | 6,870,529 | 467,196 |
| 1910 | 5,625,132 | 286,882 | 50,610,560 | 1,872,592 | 56,235,692 | 2,159,474 | (b) 1,407 | 39,710 | 13,149,000 | 945,000 |
| 1911 | 4,790,000 | 256,050 | 41,404,000 | 1,495,729 | 46,194,000 | 1,751,779 | 1,223 | 32,415 | 10,144,000 | 664,000 |
| 1912 | 3,543,771 | 187,689 | 51,286,000 | 1,709,337 | 54,829,771 | 1,897,026 | 673 | 19,344 | 12,896,347 | 830,193 |

(a) Neglecting the small re-export of foreign product. (b) Statistics of the U. S. Geological Survey. Largely graphitic shale. (c) Not reported.

[1] Edson S. Bastin, advance Chapter Mineral Resources, *U. S. Geol. Surv.*, 1913.

Prices of American flake graphite are very variable according to quality. The best flake graphite for crucibles ranged from 5 to 7 1/2 cents per pound; inferior grades not suitable for crucibles were as low as 2 1/2 cents per pound; dust produced in smaller quantity each year was from 3/4 to 2 1/2 cents per pound. The price of the higher grades was rising rapidly in the early part of 1913.

The London market at the beginning of 1913 was as follows per long ton:

As imported:
- Ceylon LL..... £18 5s. 0d. to £41 10s. 0d. per ton c.i.f. London.
- Ceylon OL..... £13 9s. 6d. to £42 9s. 6d. per ton c.i.f. London.
- Ceylon chips..... £11 5s. 0d. to £32 0s. 0d. per ton c.i.f. London.
- Ceylon dust..... £11 10s. 0d. to £29 0s. 0d. per ton c.i.f. London.

Purified, milled and ground
- Ceylon 97 to 99 per cent..... £59 0s. to £63 0s. per ton f.o.b. London.
- Ceylon 90 to 91 per cent..... £40 0s. to £42 0s. per ton f.o.b. London.
- Ceylon 80 to 81 per cent..... £30 0s. to £32 0s. per ton f.o.b. London.
- Ceylon 70 to 71 per cent..... £27 0s. to £28 0s. per ton f.o.b. London.
- American large flake..... £45 0s. to £49 0s. per ton f.o.b. London.
- American small..... £35 0s. to £45 0s. per ton f.o.b. London.
- Joint compound..... £ 2 9s. 0d. to £2 12s. 6d. per cwt.
- Paint Paste..... £ 2 12s. 6d. to £2 15s. 0d. per cwt.
- Paint..... £ 0 6s. 3d. to £0 6s. 9d. per gal.

Imports into the United States by countries were as follows with the average declared value of the product from each source:

| Country. | 1911. | | | 1912. | | |
|---|---|---|---|---|---|---|
| | Short Tons. | Value. | Value per Pound. | Short Tons. | Value. | Value per Pound. |
| Ceylon | 13,119 | $1,132,678 | 4.3 *cts.* | 16,791 | $1,379,587 | 4.1 *cts.* |
| Mexico | 3,368 | 254,060 | 3.8 | 3,518 | 163,107 | 2.3 |
| Canada | 2,289 | 78,196 | 1.7 | 2,688 | 122,216 | 2.3 |
| Japan (Chosen via Japan) | 1,256 | 18,486 | 0.7 | 1,574 | 22,875 | 0.7 |
| Austria-Hungary | 65 | 1,139 | 0.9 | 473 | 8,971 | 1.0 |
| Italy | 510 | 6,242 | 0.6 | 468 | 7,450 | 0.8 |
| Germany | 48 | 2,930 | 3.1 | 102 | 2,669 | 1.3 |
| Other countries | 47 | 1,998 | ..... | 29 | 2,462 | ..... |
| Total | 20,702 | 1,495,720 | ..... | 25,643 | 1,709,337 | ..... |

Imports for consumption are given in the table of statistics of the United States.

Exports of graphite and manufactures thereof are valued as follows for the fiscal years ending June 30:

| | |
|---|---|
| 1908 | $251,283 |
| 1909 | 293,716 |
| 1910 | 302,568 |
| 1911 | 407,423 |
| 1912 | 452,896 |

The exports of the unmanufactured domestic graphite in 1912 was 4,640,802 lb., valued $343,458; it will be noticed that this product is invoiced at nearly 7 1/2 cents per pound corresponding to a large proportion of artificial graphite. The manufactures exported in addition were valued $177,082. Graphite exported to the United Kingdom in 1910 was valued $53,390; in 1911, $29,676.

WORLD'S PRODUCTION OF GRAPHITE.
(In metric tons.)

| Year. | Austria. | Bavaria | Canada. | Ceylon. (a) | India. | Italy. | Japan. | Mexico. (b) | Sweden. | United States. (c) | Totals. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1898. | 33,062 | 4,593 | 1,107 | 78,509 | 61 | 6,435 | 347 | 1,365 | 50 | 824 | 126,353 |
| 1899. | 31,819 | 5,196 | 1,188 | 29,037 | 1,548 | 9,990 | 53 | 2,305 | 35 | 1,648 | 80,960 |
| 1900. | 33,663 | 9,248 | 1,743 | 19,168 | 1,859 | 9,720 | 94 | 2,561 | 84 | 1,799 | 79,939 |
| 1901. | 29,992 | 4,435 | 2,004 | 22,707 | 2,530 | 10,313 | 88 | 762 | 56 | 1,800 | 74,688 |
| 1902. | 29,527 | 5,023 | 993 | 25,593 | 4,648 | 9,210 | 97 | 1,434 | 63 | 1,895 | 78,371 |
| 1903. | 29,590 | 3,719 | 660 | 24,492 | 3,448 | 7,920 | 114 | 1,404 | 25 | 2,053 | 73,435 |
| 1904. | 28,620 | 3,784 | 410 | 26,478 | 2,955 | 9,765 | 216 | 970 | 55 | 2,045 | 75,298 |
| 1905. | 34,416 | 4,921 | 491 | 31,134 | 2,361 | 10,572 | 209 | 970 | 40 | 1,933 | 87,047 |
| 1906. | 38,117 | 4,055 | 405 | 36,578 | 2,642 | 10,805 | 177 | 3,915 | 37 | 2,220 | 98,909 |
| 1907. | 49,425 | 4,033 | 525 | 33,027 | 2,472 | 10,989 | 103 | 3,202 | 33 | 2,080 | 105,889 |
| 1908. | 44,425 | 4,844 | 227 | 26,227 | 2,919 | 12,914 | 177 | 1,076 | 66 | 1,557 | (d) 101,952 |
| 1909. | 40,710 | (e)4,900 | 783 | 25,995 | 3,182 | 11,583 | 284 | (e)1,100 | 26 | 2,572 | 91,135 |
| 1910. | 33,131 | 7,415 | 1,263 | 30,008 | 4,056 | 12,510 | 145 | 2,332 | 49 | 2,552 | 93,461 |
| 1911. | 41,599 | 11,298 | 1,154 | 27,433 | 4,112 | 12,621 | 114 | 2,865 | 65 | 2,177 | 103,438 |

(a) The figures for 1897, 1899, 1907, and 1908 are exports; the enormous production in 1898 as reported in official government publications is not reflected in the exports of that year which amounted to 24,349 metric tons. (b) Exports. (c) Crystalline graphite. (d) Includes the production of 7,520 metric tons in Korea. (e) Estimated.

In the United States only two or three graphite mines or plants (flake graphite), are producing. Of the thirty or more projects that have been unsuccessful one or two are being remodelled, the remainder are shut down.

*Alabama.*—The Allen Graphite Company, now the Quenalda Graphite Co., at Quenalda, is to replace its mill destroyed by fire. The new mill is to treat 400 tons of rock in ten hours. Of the total product formerly only one-third was crucible flake graphite. The Alabama Graphite Co. is developing a new property near Ashland. Production amounts to only 1 per cent. of the total output of the United States. In 1910, 1,577,977 lb. were produced; in 1911, 820,000 lb. and less in 1912.

*Alaska.*—Near Graphite Bay, Port Clarence Mining district, schists containing graphite are to be worked by the Uncle Sam Alaska Mining Syndicate. Another company, the Alaska Graphite Co., in the same district, made no shipments, but developed its property.

*California.*—A graphite deposit near Saugus, Los Angeles Co., is to be developed.

*Colorado.*—An occurrence of graphite in veins 4 to 6 ft. thick is reported at the head of Cement creek, summit of Italian Mountains, Gunnison Co. Development work is being done by the Colorado Graphite Mining and Manufacturing Co.

*Michigan.*—Graphitic slate is prepared for paint by the Detroit Graphite Co. near L'Anse. This is the only producer.

*Montana.*—The Crystal Graphite Co. is developing its property near Dillon.

*Nevada.*—Paint and graphite for foundry facings is produced by the Black Lead Mining Co. near Carson.

*New Mexico.*—The amorphous graphite on the Canadian River, 7 miles southwest of Raton, is described by W. T. Lee.[1]

*New York.*—This state is the chief producer. The largest operator as in recent years was the American mine at Glaphite; other operators were the Empire Graphite Co., at Greenfield, Saratoga Co. and the Sacandaga Graphite Co., at Conklingville. For details see Mineral Industry, XX. p. 380.

*Pennsylvania.*—The firms reported as operating in the state in 1912 are Pettinos Bros. at Byers, and the Acme Graphite Company.

The mines formerly known as the Pennsylvania and the Continental are now worked by the Acme Graphite Company of New York. They are the westerly deposits of those extending from Pikeland to Byers, Chester County, Penn. In 1876, flake graphite was sold from the older of these mines, which is the "Pennsylvania," but it appears that only rich material containing 30 per cent. carbon was gouged.[2]

The deposits are in pre-Cambrian sediments, extending east and west. The graphite occur in quartzite. The crystallization of the carbonaceous matter was intensified by pegmatite dikes. The quartzite in the Continental is about 5 ft. in thickness, and at present confined to a lens 150 ft. long. In the Pennsylvania, three principal quartzite strata are worked at the present time, and indications of a fourth stratum underlying these are found. Indications for the extent of the graphite to a reasonable depth are good. The deposit is continuous for a distance of 1500 ft. and would average 10 ft. in thickness, being in places 30 ft. thick. The mining is carried on by both open-cut and underground work, and filling is used in the stopes. There are two classes of ore which are concentrated by different methods. The flow-sheet of the hard ore mill is shown in Fig. 1. The capacity of ten stamps crushing 8 mesh is about 120 tons per 24 hours. The jigs are of the type used in some of the New York garnet mines. It is believed that a New Century coal-jig would be better.

The soft ore occurs in a softer gang, much of the graphite breaking free. The material is crushed in Sturtevant rotary crushers, provided with manganese parts. Fig. 2 gives the flow sheet of this mill.

Up to a short time ago no saving of graphite finer than 60 mesh was attempted, but in some experimenting a method of separating this material from the fine sand was devised by dewatering through a 100-mesh silk reel, the over-product being fed to a cement table which ied off the graphite but retained the sand. When this product is d through the finishing mill, it yields a grade of dust worth 2 to 3

[1] L. *U. S. Geol. Surv.*, 1912.
[2] Seattle, *Eng. and Min. Journ.*, July 20, 1912, p. 115.

cents a pound. No experiments have been made with a Frue vanner. A buddle cannot be used as the agitation of the brushes prevents separation. The carbon extraction by the means employed, namely, the

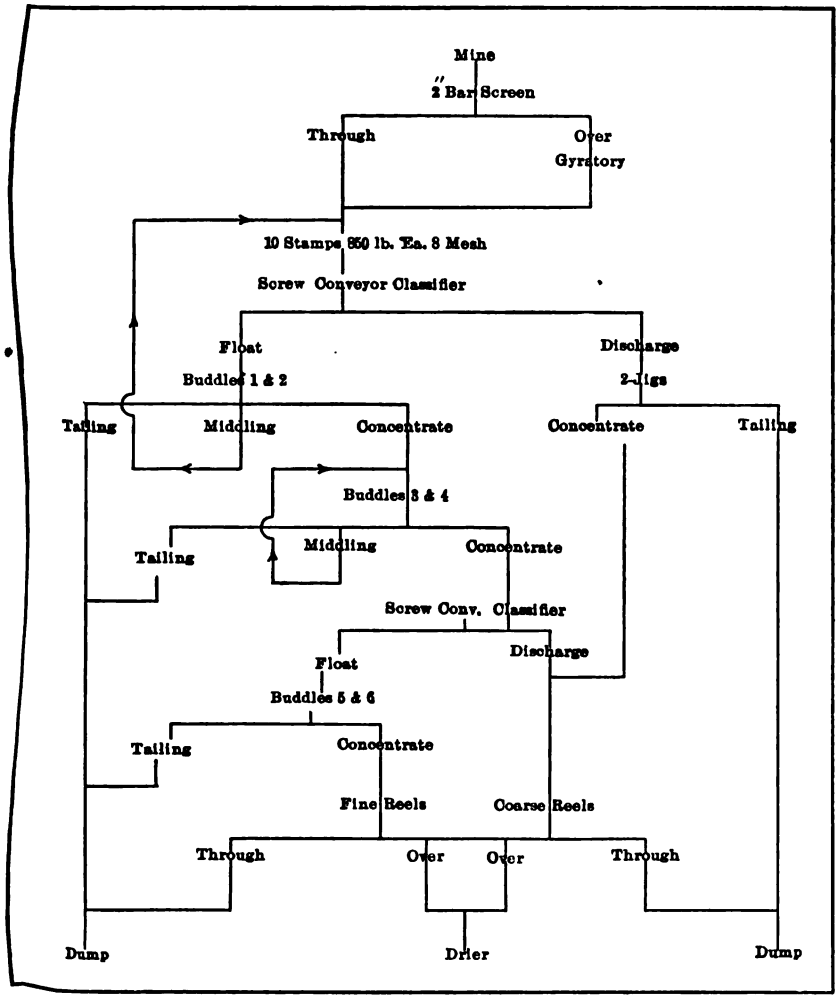


FIG. 1.

cement table following the reels, has been brought up to 35 to 43 per cent., with a concentrate assaying 60 to 70 per cent. carbon, as compared with 35 to 50 per cent. with former methods. The loss in slimes is therefore still considerable, as shown by the following table:

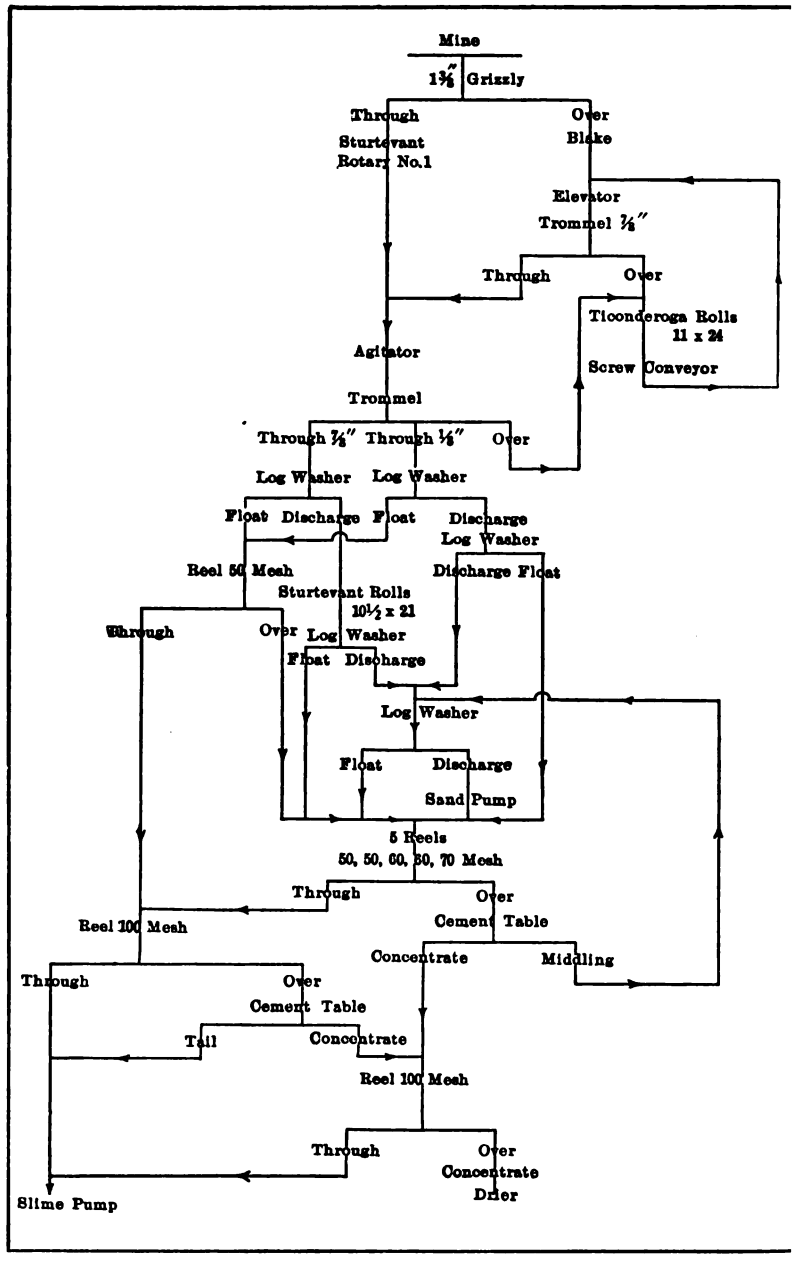
Mine
1¾" Grizzly
Through
Sturtevant
Rotary No.1
Over
Blake
Elevator
Trommel ⅞"
Through
Over
Ticonderoga Rolls
11 x 24
Screw Conveyor
Agitator
Trommel
Through ⅞"
Through ½"
Over
Log Washer
Log Washer
Float Discharge
Float Discharge
Log Washer
Reel 50 Mesh
Discharge Float
Sturtevant Rolls
10½ x 21
Through
Over
Log Washer
Float Discharge
Log Washer
Float Discharge
Sand Pump
5 Reels
50, 50, 60, 60, 70 Mesh
Through
Over
Reel 100 Mesh
Cement Table
Concentrate
Middling
Through
Over
Cement Table
Tail
Concentrate
Reel 100 Mesh
Through
Over
Concentrate
Slime Pump
Drier

FIG. 2.

| | Tons per day. | Assaying in carbon. | Tons carbon per day. |
|---|---|---|---|
| Ore | 35.2 | 6.35 | 2.235 |
| Sand tailings | 14.5 | 1.02 | 0.148 |
| Concentrates | 1.72 | 58.82 | 1.006 |
| Slimes (by difference) | 19.02 | 5.68 | 1.081 |

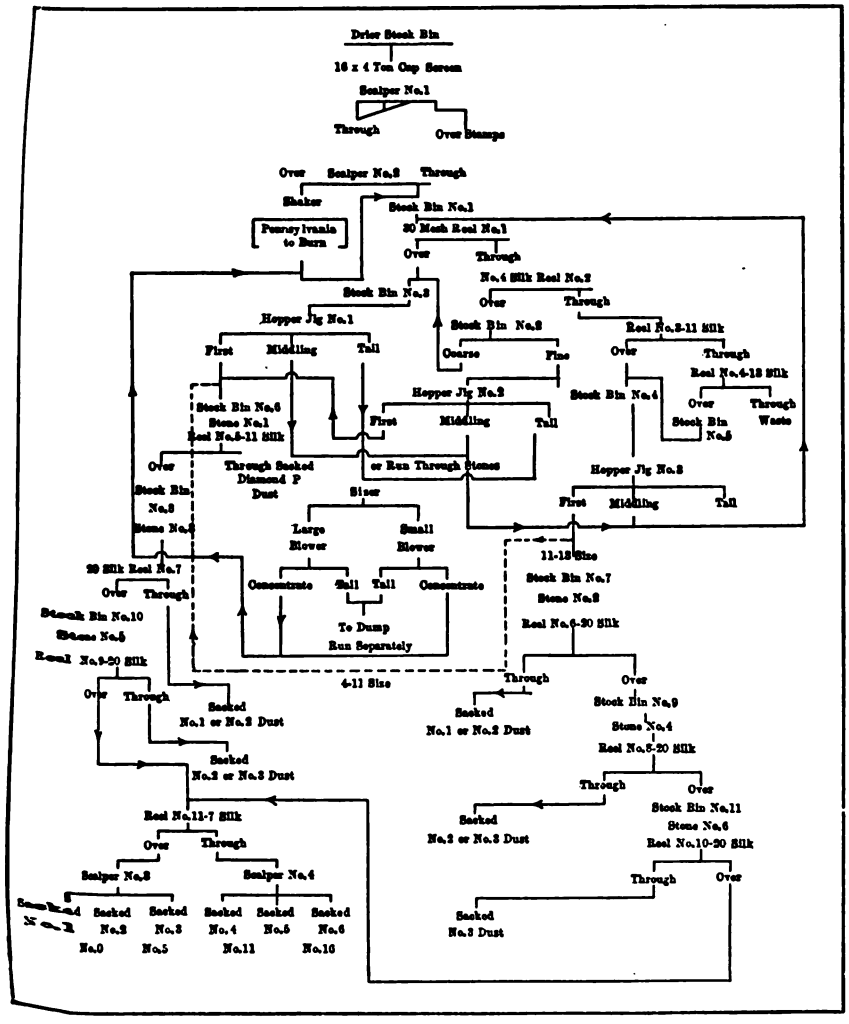


FIG. 3.

The concentrate from this mill is dried in a rotary kiln at a red heat, in order to burn out any wood and to change the physical character of the mica.

The flow sheet of the finishing mill is given in Fig. 3. Since 35 per cent. concentrate is being finished, the product called "P" dust has been reduced from 20 per cent. to 4 per cent. of the whole output. The stones used in the grinding and polishing are French Buhrs dressed as in flour mills. The stones require dressing once in six weeks. The elimination of the mica is a difficult matter if it once gets to the finishing mill. The better grades of flake do not contain more than 1 per cent. of iron, probably chemically combined with the mica and hence difficult to eliminate by magnetic or other separators. The ore is simply carefully sorted and thoroughly burned in the drier to prevent mica. The statement is made by E. Goodwin Steele,[1] that Sutton, Steel and Steele dielectric separators readily separate a concentrate of mica and flake graphite.

Another difficulty in the market is to keep the quality uniform. Ceylon graphite is uniform, and can be landed in New York at the same price that flake graphite can be produced in this country. It is estimated that on a basis of 150 tons of output per day, the cost including depreciation, does not exceed $4 per ton of ore. On this basis the cost per ton of finished product, based on 6 per cent. ore, would be $70.

The question of improving the extraction, therefore, is at the bottom of expanding the American flake graphite industry. Another outlet for this product for the finer flake grades is in lubricants, although it is a disputed question whether graphite adds materially to lubricating properties.

*Texas.*—In the Llano and Burnett region of Texas, graphite schists are associated with lime-stone and marble. The only deposit of possible commercial value is located 1 7/8 miles due south of Lone Grove, about 800 ft. north of the Houston and Texas Central Railroad. The schists are much disturbed with pegmatite intrusions. In the shaft and cross-cuts, about 5500 tons of 12 per cent. graphite rock is revealed. The deposit requires more prospecting.

*Wisconsin.*—The Wisconsin Graphite Co. at Stevens Point produces amorphous material for paint.

## Foreign Countries

*Canada.*—The value of graphite exported from Kingston, Ont., to the United States, was $20,482 during the year 1911, and $36,027 during 1912.

The graphite comes from the mine of the Black Donald Graphite Co., which operates its mill all the year and its mines during the summer

[1] *Eng. and Min. Journ.*, July 13, 1912.

months. The refined graphite is hauled to Calbogie, a distance of 12 miles, for shipment.

The graphite produced in Quebec in 1912 was 1,210,278 lb. valued $50,680; this value in 1911 was $33,613 for 377 tons. The Ontario graphite production in 1911 was 894 tons valued $36,492; and in 1912, 1246 tons valued $65,076. The Canadian production of 1912 was valued $104,393; the exports were 33,074 cwt., worth $70,763.

The companies producing in Quebec during 1912 were the following: Buckingham Graphite Company, Bell Graphite Co., Peerless Graphite Co., Dominion Graphite Co., all in the township of Quebec. The Dominion Graphite Company has a mill of 250 tons ore, daily capacity. The gneisses in this vicinity carry up to 40 per cent. of graphite. Ores containing mica are generally considered unworkable.

In the township of Amherst, on the Canadian Pacific Railway, 80 miles from Montreal, deposits of graphite will be worked by the "Graphite Limited." The country rock consists of crystalline gneiss and limestone cut by numerous dikes. The ore occurs in zones as exposed thus far on the surface 10 or 12 ft. wide. Masses of pure graphite from 1 in. to 2 cu. ft. are exposed and can be cobbed from the crude ore. The crude ore is said to contain 65 per cent. carbon. The larger proportion of the ore is to be milled according to a process installed by Mr. C. Brewer. An analysis of the ore gives the following mineral composition:

| | |
|---|---|
| Graphite (carbon) | 54.75 |
| Feldspar | 34.32 |
| Lime | 5.42 |
| Carbonic acid gas | 4.26 |
| Volatile matter | 1.12 |
| Moisture | 0.13 |
| | 100.00 |

The ore contains no objectionable mica or pyrites.

*Ceylon.*—Since 1901 the United States is the chief consumer of this graphite. The exports are as follows:

EXPORTS OF GRAPHITE FROM CEYLON, IN SHORT TONS.

| Destination | 1885(a) | 1902(a) | 1912(b) |
|---|---|---|---|
| Great Britain | 7,670 | 7,586 | 6,125 |
| United States | 3,074 | 15,244 | 17,374 |
| Germany | 67 | 3,833 | 9,122 |
| Belgium | ..... | 1,096 | 3,224 |
| Other countries | 187 | 453 | 833 |
| Total | 10,998 | 28,212 | 36,668 |

(a) Figures from Ceylon Government Blue Book.
(b) Ceylon customs.

The only important mine where the product is prepared for final shipment is the Medapola. Two hundred mines are worked by natives but some are only shallow prospects.

*Chosen.*—Extensive amorphous graphite deposits occur in nearly all parts of Korea, especially in the southern, northeastern and northern districts.[1] The quality, however, is inferior, the carbon contents of the mineral averaging no more than 60 per cent. A fairly soft and good quality with more than 80 per cent., and fit for export, has so far been found in a few mines only. Working costs are low, so far as mining itself is concerned, but, as all the properties are situated far from shipping places and good roads are scarce, transport is difficult and expensive. The total production amounted in 1906 to 1000 tons, in 1907 to 5000 tons, in 1908, 18,000 tons, in 1909, 18,000 tons, in 1910, 12,000 tons, in 1911, 10,000 tons. Nearly all the exported product is shipped via Japan. In 1912[2] the imports from Chosen were 27,332 short tons; 5359 tons were re-exported; 548 tons were produced in Japan. For export the graphite is packed in barrels of 320 lb. each, present prices for best amorphous being £5 5s. c.i.f. London, £4 15s. c.i.f. Amsterdam, and $25 c.i.f. New York. The low level of prices is due to overproduction since 1909 and to the fact that large consignments shipped by speculators to Europe and America, having remained for years without finding buyers, had at last to be sacrificed for next to nothing.

*Germany.*—The imperial Ministry has compiled data from the various manufacturers in the graphite industry in Germany, as follows:

| Graphite. | 1909. | 1910. | 1911. |
|---|---|---|---|
| Number of companies | 32 | 31 | 29 |
| Number of employees | 166 | 181 | 255 |
| Number of producing mines | 44 | 44 | 39 |
| Production: | | | |
| Metric tons | 6,160 | 7,035 | 11,815 |
| Value | $53,574 | $55,672 | $81,695 |

The graphite produced in Bavaria in 1911 amounted to 11,298 tons, and was valued at 298,575 marks. About 1000 persons are employed in this industry and more than half of these are women. For 1910, 7415 tons valued at 313,500 marks were produced. The number of workmen in 1910 was only 264, whereas in 1911, 438 men were employed.

*Italy.*—The value of the graphite produced from twenty-six establishments in 1910 in Italy was 12,510 tons, valued at 384,290 lires; from 30 in 1911, 12,621 tons, valued 383,744 lires and in 1912, 13,170 tons.

*Madagascar.*—The flake-graphite deposits of Madagascar are of increasing interest, although none has yet been exported to the United States.[3] In 1909 the Madagascar exports were 200 metric tons; in 1910, 554

[1] *Min. Journ.*, July 27, 1912.
[2] Nagasaki Press.
[3] *Daily Cons. and Trade Reports*, Jan. 29, 1913.

metric tons; 1911, 1281 tons; and in the first half of 1912, 1121 tons. On Dec. 31, 1911, only 200 claims were located, as against almost 400 on July 1, 1912.

The veins are found in decomposed quartzite and rotten feldspar, and extend nearly the whole length of the island, beginning a little to the south of the Mountain d'Ambre in the north and extending to Ambalavao in the south. The deposits being worked at present, however, are in the central plateau and on the east coast, principally in the environs of Tananarive, Mamjakandriana, Vatomandry, Andeveranto, Maevatanana, Betafo, Antsirabe, Ambositra, Fianarantsoa, Fort Carnot and Ambalavoa, extending about 250 miles.

The Madagascar graphite may be easily separated from the débris by simply washing it with the hands and, if the work is carefully done, may be concentrated up to 80 or 85 per cent. The graphite thus far produced, however, has averaged from 70 to 80 per cent., due to the fact that it has been washed almost wholly by natives with pans or sluices, the latter method giving the better results. By the use of machinery it is estimated that the concentrate may be brought up to 95 or 98 per cent. As the decomposed quartzite and rotten schists retain moisture, only machinery suitable for handling such materials should be employed. Only three of the large producers of graphite have as yet installed machinery at their plants. These are the Maison Suberbie and the Syndicat Lyonnais, at Tananarive, and Arton and Allemand, at Mamjakandriana, with European headquarters at Antwerp. A French company for working Madagascar graphite, the Graphite Maskar, has been formed.

The present price of Madagascar graphite varies from $38.60 to $135 per ton, f.o.b., according to the percentage of carbon and size of the flakes. Graphite averaging 80 per cent. carbon sells for $67.55 to $77.20, and that averaging 88 to 90 per cent. for $130.28. The freight per metric ton on graphite, as quoted by the Messageries Maritimes Steamship Co., is $17 from Tamatave to New York, and $20 from Vatomandry and Mananjary, the two southern ports from which graphite is shipped.

*Mexico.*—The graphite declared for export from Mexico to the United States, in 1911, was worth $71,411.

The exports of graphite from Mexico were valued at 62,504 pesos for the year 1910 and 35,800 pesos in 1911. The exports in 1911 were 2865 tons as compared with 2332 tons in 1910. These figures though official are evidently not complete. The exports into the U. S. for the fiscal year 1912 were 1860 metric tons valued 92200 pesos.

*Graphite Electrodes.*—Artificial carbon electrodes are used for furnaces and also in electrolytic work. In Europe common amorphous electrodes are in use, although the graphitized electrode first introduced on

any scale by Dr. Acheson is also used. This is largely a matter of cost; the method of manufacture of graphitized electrodes may be defective but undoubtedly these properly made are superior in standing wear and tear. In furnace work it is realized that electrode economy may vary 100 per cent. owing to differences in manufacture. The amorphous carbon electrodes may also be poorly manufactured, so that in making comparison many points must be considered.

Among the properties of carbon electrodes the following may be stated:[1]

Losses from electrodes used in 20 per cent. salt solution with 1 ampere per square centimeter density as determined by tests are:

| | GRAMS PER 10 AMPERES PER HOUR. |
|---|---|
| Conradty (carbon) | 5.17 |
| Le Carbon (graphitized) | 2.80 |
| Plania Works (carbon) | 1.90 |
| Schiff & Co. "N" (carbon) | 5.65 |
| Retort carbon | 2.92 |
| Acheson graphitized | 1.06 |
| Harden's graphitized | 2.02 |

If too fine and deep black, too much dust and lampblack have been used. A gray light structure with light points and globes indicates too much petroleum coke. Each particle of a good carbon electrode should be surrounded by binder, and an even grain not too fine should result. Improper calcining, usually in a gas furnace on a coke dust bed, may cause faults. A good amorphous carbon should give a clear ring, as of cast iron, when struck with a bar and should bear rough handling. The graphitized electrode, on the other hand, gives a clear thud; it is capable of polishing with an iron. The amorphous carbon is hard and cannot be cut except by emery wheel or chisel. The porosity must not be excessive. Graphitized electrodes show as a rule very low content of ash, due to the high temperatures of treatment. For electrolysis they should not have more than 2 1/2 to 3 per cent. ash. Good carbons from petroleum coke and lampblack have usually 0.3 to 0.5 per cent. of ash, while anthracite electrodes have 3 to 4 per cent. For carbide furnaces 3 to 4 per cent. lime, and for steel furnaces 1 to 3 per cent. iron is permissible, but higher percentages shorten the life. In micrographs it can be seen that no trouble from insufficient calcining is to be expected in graphitized electrodes as the binder is practically all converted into graphite. The resistance is of importance and power wasted may exceed saving in cost of electrodes. The relative resistances are 150 for charcoal electrodes, 58 to 75 for amorphous carbons and 6 to 12 for graphite.

Acheson graphite electrodes have been found remarkably constant in resistance up to a temperature of melting nickel, say 1500° C.[2]

[1] John Harden, *Met. and Chem. Eng.*, Vol. XI, No. 5.
[2] E. F. Northorp, *Chem. and Met. Eng.*, Vol. XI, No. 5.

The expansion of Acheson and other graphites[1] and carbon is compared and the conclusion is reached that the constitution varies and with it the expansion and other physical properties.

An experiment to show the action of carbon and of graphite by passing a current through a rod of each shows the properties. The graphite rod becomes quickly incandescent, the carbon remains dark for a time; the resistance of the latter then decreases with the temperature rise and becomes quickly brilliant, the graphite rod decreasing in brilliancy. The author concludes that for small furnaces, at least, graphite gives an easier regulation.

*Graphite Crucibles.*—According to information by the Joseph Dixon Crucible Co., the following facts are useful in handling graphite crucibles. Uneven heating of the crucible may result in the "scalping," and the expansion of a more highly heated portion is sufficient to rend it apart from the cooler portions. The cooler portions may result from the presence of water. Crucibles will easily absorb 5 per cent. of water. In heating crucibles a large excess of air, or with fuel oil, an excess of steam, may cause consumption of the carbon making the pots porous.

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[1] A. L. Day and Robert B. Sosman, *Journ. Ind. and Eng. Chem.*, Vol. IV, No. 7, July, 1912.

# GYPSUM

The output of crude gypsum in the United States in 1912 was 2,550,757 short tons, an increase of 176,787 tons, or 7.6 per cent., over 1911 and constituting the largest annual output yet recorded. Gypsum was mined in seventeen states and Alaska, 76 mills being engaged in grinding or calcining the material. Of the total crude output, 53,065 tons were ground and sold for land plaster at an average price of $2.02 per ton; 388,543 tons were ground and sold, without calcining, for the manufacture of Portland cement, etc., at an average price of $1.33 per ton; and 1,731,674 tons were calcined into plaster Paris, wall plasters, etc., and sold at an average price of $3.43 per ton.

PRODUCTION OF CRUDE GYPSUM IN THE UNITED STATES. (a)
(In tons of 2000 lb.)

| State. | 1910 | | 1911 | | 1912 | |
|---|---|---|---|---|---|---|
| | Tons. | Value. | Tons. | Value. | Tons. | Value. |
| California, Nev., and Oregon | 149,230 | $695,121 | (b)177,815 | $650,319 | 170,149 | $688,247 |
| Iowa | 322,713 | 943,849 | 354,204 | 857,287 | 411,186 | 845,628 |
| Kansas | 135,088 | 377,222 | 122,579 | 345,203 | 131,031 | 324,820 |
| Michigan | 357,174 | 668,201 | 347,296 | 573,926 | 384,297 | 621,547 |
| New York | 467,339 | 1,153,977 | 472,834 | 1,199,596 | 506,996 | 1,241,514 |
| Ohio and Va. | 292,987 | 821,213 | 360,858 | 1,056,568 | 262,551 | 812,388 |
| Tex. and Okla. | 351,347 | 941,256 | 288,278 | 773,753 | 295,937 | 825,197 |
| Utah | 46,279 | 149,089 | (d) | ..... | (c) | ..... |
| Wyoming | (c) | ..... | 44,687 | 116,237 | 36,581 | 89,982 |
| All other States | 256,900 | 773,101 | 155,419 | 889,146 | 302,029 | 1,314,575 |
| Total | 2,379,057 | $6,523,029 | 2,323,970 | $6,462,035 | 2,500,757 | $6,563,908 |

(a) Statistics of the U. S. Geol. Surv. (b) Includes Utah. (c) Included in Other States. (d) Included in Cal. and Nev.

CRUDE GYPSUM MINED IN UNITED STATES. (a)
(Tons of 2000 lb.)

| | | | | | |
|---|---|---|---|---|---|
| 1880 | 90,000 | 1892 | 256,259 | 1904 | 940,917 |
| 1881 | 85,000 | 1893 | 253,615 | 1905 | 1,043,202 |
| 1882 | 100,000 | 1894 | 239,312 | 1906 | 1,540,585 |
| 1883 | 90,000 | 1895 | 265,503 | 1907 | 1,751,748 |
| 1884 | 90,000 | 1896 | 224,254 | 1908 | 1,721,829 |
| 1885 | 90,405 | 1897 | 288,982 | 1909 | 2,252,785 |
| 1886 | 95,250 | 1898 | 291,638 | 1910 | 2,379,057 |
| 1887 | 95,000 | 1899 | 486,235 | 1911 | 2,323,970 |
| 1888 | 110,000 | 1900 | 594,462 | 1912 | 2,500,757 |
| 1889 | 267,769 | 1901 | 633,791 | | |
| 1890 | 182,995 | 1902 | 816,478 | | |
| 1891 | 208,126 | 1903 | 1,041,704 | | |

(a) Statistics of the U. S. Geol. Surv. (e) Estimated.

## GYPSUM MINING IN THE UNITED STATES

*Nevada.*—The gypsum found adjoining the Ludwig mine, owned by the Nevada-Douglas Copper Mining Co., in the Yerington district, Lyon County, Nev., is being worked by open quarries. The gypsum is 96 per cent. pure, and is known to extend to a depth of 400 ft. The deposit has been developed for a length of 2000 ft., and a width of 200 ft. The output is shipped at the rate of 100 tons per day to the Pacific Portland Cement Co. of Reno. The production is to be increased shortly to 300 or 400 tons per day. For description of this deposit, see paper by A. F. Rogers.[1]

*New York* (By D. H. Newland).—No important changes occurred last year in the gypsum business, the list of producing companies remaining the same, practically, as given in Vol. XX of THE MINERAL INDUSTRY, but the output was a little larger than in 1911. The total amount of rock mined or quarried exceeded 506,000 tons. A little more than one-third of the output was sold crude, mainly to Portland cement makers, and the remaining two-thirds was converted into calcined plasters. From a technological standpoint, the most important event of the year was the erection of a new calcining plant at Oakfield by the U. S. Gypsum Co. The plant is equipped with five vertical kettles, giving the company much the largest capacity of all the manufacturers in the State, and also indicating the continued preference in the district for the kettle process over the rotary cylinder, or Cummer method of calcination.

PRODUCTION OF GYPSUM IN NEW YORK.

| | 1911. | | 1912. (a) | |
|---|---|---|---|---|
| | Short Tons. | Value. | Short Tons. | Value. |
| Total output, crude | 446,794 | ..... | 506,996 | ..... |
| Sold crude | 144,035 | $202,984 | 170,448 | $224,704 |
| Ground for land plaster | 9,959 | 18,508 | 10,498 | 23,248 |
| Wall plaster, etc., made | 262,249 | 871,106 | 274,155 | 993,562 |
| Total value | ..... | $1,092,598 | ..... | $1,241,514 |

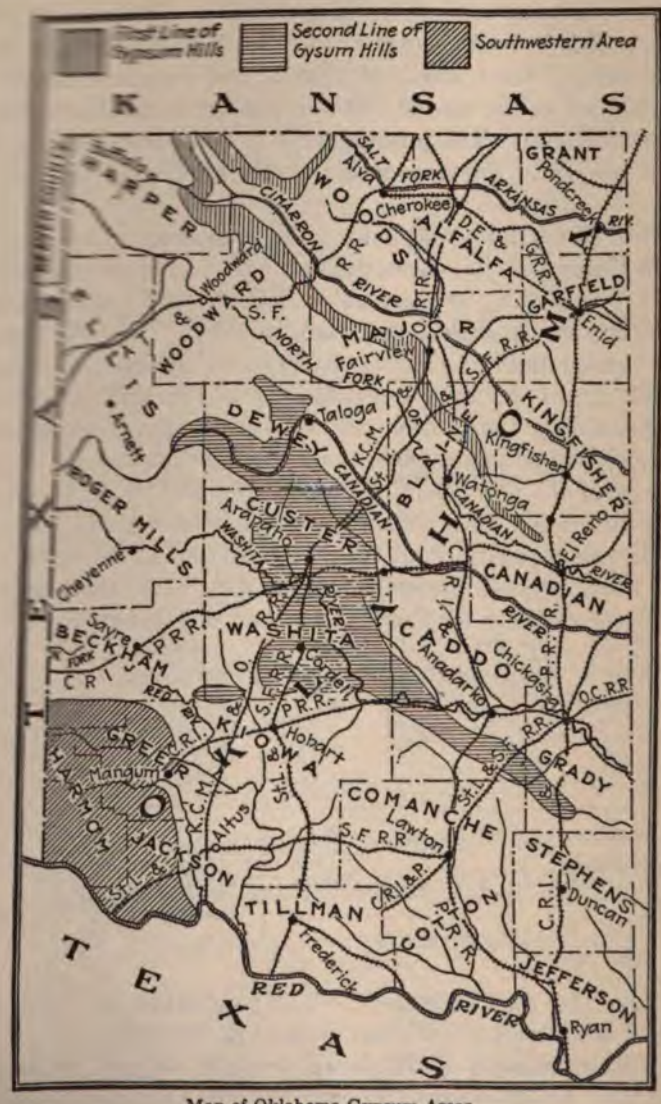
(a) U. S. Geol. Surv.

*Oklahoma* (By L. C. Snider).[2]—The production of crude gypsum during 1912 was about 90,000 tons, valued at $200,000.

The gypsum deposits of Oklahoma occur in the western part of the state, and may be classified as follows: (1) The first line of gypsum hills; (2) the second line of gypsum hills; (3) the southwestern area. The rocks of the entire region are the Permian redbeds. (See map.)

[1] *Econ. Geol.*, Feb.–Mar., 1912.
[2] *Eng. and Min. Journ.*, May 10, 1913.

The first line of gypsum hills enters the state from Kansas on the south side of the Salt Fork of the Arkansas River and, swinging back on the northeast side of the Cimarron, crosses it just north of the Kansas




Map of Oklahoma Gypsum Areas.

and then follows down the southwest side of that stream as far as the y of El Reno, where it dies out. The line crosses parts of Woods, Woodward, Major, Blaine, Kingfisher and Canadian Counties.

Throughout this district there are usually three beds of gypsum, which vary considerably from place to place in thickness, character and the distance by which they are separated. They are interstratified with extremely soft red and green shales and red sandstones. Each ledge is underlain by greenish dolomitic sandstone which varies in thickness from 1 or 2 in. to 3 ft. or a little more. In spite of the soft character of the gypsums, they are much more resistant than the sands and shales with which they are associated, and consequently form the cap of the escarpment and of the numerous buttes and outliers which occur along the range.

In the northwestern part of the area, from the Kansas line to Fairview, the gypsum beds are each 10 ft. or more in thickness and are separated by only a few feet of shale. The gypsum is made up of crystals of selenite pointing in all directions, and reaching a size of 2 in. or more in length.

Southeast from Fairview the beds change from the selenitic form to a dense, fine-grained structure, and at the same time become somewhat thinner, while the intervening shales become thicker. In the middle one of the three ledges is a bed of anhydrite which varies in thickness from a few inches to 4 or 5 ft. Locally anhydrite is not a continuous bed, but occurs as boulders or lentils. In this region the hills are even more pronounced than to the northwest, the exposures of gypsum are sharper and the effects of solution much less evident. This type of development is best shown in the northern part of Blaine County. Here the anhydrite in the middle gypsum is at its greatest thickness, forming a conspicuous white band at or near the top of the hills and breaking off in large rectangular blocks. Southeast from Watonga the gypsums thin rapidly and the hills decrease; the gypsums become lenticular and the three ledges lose their identity and finally disappear a few miles north of El Reno.

The second line of gypsum hills occupies a large area, principally in Dewey, Custer, Washita and Caddo Counties. The stratigraphy of the redbeds is very irregular in this region, and the gypsum beds are lenticular, are not continuous over large areas, and vary greatly in thickness. A gypsum ledge may grade into gypsiferous sandstone within the distance of a few rods. In the northern part of the area there is only one gypsum ledge of any importance, but in the southern part, near Weatherford, in southeastern Custer County, and in eastern Washita County, as many as four or five ledges may show on a hillside and single ledges 65 ft. in thickness at the outcrops have been measured. Ledges over 100 ft. thick have been reported in borings. The character of the gypsum also varies considerably, alterations from fine-grained,

massive gypsum to coarsely crystalline selenite, and from pure white to red or green colors, showing in a single ledge within short distances.

The southwestern area occupies all of Harmon, southeastern Beckham and western Greer and Jackson Counties. The gypsums resemble those of the second line of hills. They are, however, more regular in their stratification and five ledges usually show distinctly. The best exposures of these gypsums in Oklahoma occur along the Salt Fork of the Elm River. Five ledges are well shown in this region and two of these are rather thick, reaching 20 ft. as a maximum.

Gypsite or gypsum earth is used at the majority of the Oklahoma mills, either alone or in connection with rock gypsum. This material is found usually in the valleys of the small streams in the gypsum regions, but does not seem to have been washed down from the hills. It is apparently formed by the water from gypsum springs or that which works down the slopes. This water is gypsiferous and when it evaporates from the soil in the valleys, the gypsum is left in the soil. The deposits of gypsite vary in size from a few square feet to those covering 400 acres. The thickness of the deposits also varies considerably, 12 to 15 ft. being the maximum. Workable beds of gypsite are known in Blaine, Custer, Washita, Grady, Stephens, Caddo, Jackson and Harmon Counties.

At present there are 12 plaster mills in Oklahoma. Over half of these are in northern Blaine County, where the gypsums of the first line of hills are well developed and where the railway facilities are good. The mills in this county are those of the American Cement Plaster Co., at Watonga, the Monarch Plaster Co., at Watonga, the Southwestern Plaster Co., at Okeene, the Oklahoma Gypsum Co., at Wilson, the United States Gypsum Co., at Southard, the Roman Nose Gypsum Co., at Bickford, and the Rubey Stucco-Plaster Co., at Ferguson. The other mills on the first line of hills are those of the Oklahoma Plaster Co., at Alva, which uses rock quarried at Quinlan, and of the U. S. Gypsum Co., southwest of Okarche. The only mill in the second line of hills is at Bush Springs, in Grady County, where the Acme Cement Plaster Co. has a new steel and concrete mill, the only fireproof mill in the state. Mills belonging to the same company at Marlow and Cement have burned in the last few years. In the southwestern area the only mill is that of the U. S. Gypsum Co., at Eldorado, in Jackson County. The last two mills use gypsite exclusively, while the others use rock gypsum or the rock and gypsite together. One mill is situated at McAlester, in the center of the coal fields.

Very little gypsum is sold for land plaster in Oklahoma. Between 8000 and 10,000 tons are sold annually to Portland-cement mills. The

great bulk of the production is calcined and sold as some form of plaster. In the last few years, the making of partition block has become an important branch of the gypsum industry. The value of the annual production of gypsum and its products in Oklahoma has varied from $300,000 to $450,000 for the last few years.

*South Dakota.*—The gypsum plants at Rapid City and Hot Springs had a prosperous year in 1912. The National Alabaster Co. began operations at Alabaster, near Hot Springs.

*Utah.*—The gypsum beds along the west flank of the San Rafael Swell are described by Charles T. Lupton.[1]

No working mines exist, but a number of prospects are opened. The natural exposures are such that prospecting is practically unnecesary Transportation facilities are lacking. One railroad grade, connecting Green River with Price, crosses the gypsum beds, but the road has never been used. If 10 ft. is assumed as the thickness of the upper gypsum bed, and 30 ft. for the lower bed, and further assuming that the beds could be mined for a distance of two miles from the outcrop, down on the dip, which is three to five degrees, the beds are estimated to contain 9,700,000,000 tons. The gypsum in the lower bed is probably the purer, the upper containing chert and various colors. Analyses of gypsum from various localities in the United States are given in the following table:

ANALYSES OF CRUDE GYPSUM.

| Locality. | Percentage of Gypsum. | CaO. | $SO_3$. | $H_2O$. | Cl. | $Fe_2O_3$. |
|---|---|---|---|---|---|---|
| Palmdale, Cal. (*a*) | 72.1 | 27.5 | 33.5 | 15.6 | Trace | 1.3 |
| Kern county, Cal. (*b*) | 79.5 | 28.76 | 37.06 | 17.3 | Trace | 0.71 |
| Alabaster, Mich. (*c*) | 99.3 | 32.33 | 46.18 | 20.96 | 0.03 | 0.08 |
| Black Hills, S. Dak. (*c*) | 97.7 | 32.44 | 45.45 | 20.80 | ..... | ..... |
| Nephi, Utah. (*c*) | (*d*) | 35.29 | 48.14 | 15.88 | Trace | ..... |
| Fullers Bottom, Utah | 97.3 | 32.47 | 45.63 | 20.54 | 0.32 | Trace |
| Horn Silver Gulch, Utah | 97.9 | 32.49 | 45.88 | 20.58 | 0.39 | Trace |

(*a*) Hess, F. L., U. S. Geol. Surv., *Bull.* 413, 1910, p. 30. (*b*) Hess, F. L., U. S. Geol. Surv., *Bull.* 430, 1909, p. 418. (*c*) Clarke, F. W., U. S. Geol. Surv., *Bull.* 491, 1911, p. 220. (Analyses *B*, *C*, and *D*). (*d*) Probably contains anhydrite.

The gypsum-bearing rocks in this region are Upper Jurassic; there are two zones, one 200 ft. below the top of the series, and one 200 ft. above the base. The total thickness of the series is 1350 ft. Very little selenite or crystalline gypsum is noted. The gypsum at one locality, at the east end of Fullers Bottom, contains no anhydrite. A characteristic is the large amount of chlorine, being nearly ten times more than that in the gypsum of Alabaster, Mich.

[1] U. S. Geol. Surv., *Bull.* 530-N, 1913, p. 221.

*Virginia.*—The gypsum deposits of southwestern Virginia, together with those of salt, occur along a belt 20 miles long, northeastward from Plasterco. Two gypsum plants and one salt and alkali works are located in this area. Transportation facilities are poor and many prospects are not worked for this reason. The Saltville branch of the Norfolk & Western Railway, which joins the main line at Glad Spring, connects with the valley of the North Fork of the Holston River. The two gypsum companies operating in this region at the present time are the United States Gypsum Co., at Saltville, and the Southern Gypsum Co. at North Holston.

## Gypsum in Foreign Countries.

*Canada.*—Gypsum has been quarried or mined for many years in Nova Scotia and New Brunswick, and to a smaller extent in Ontario. During the past 12 years gypsum deposits north of Lake St. Martin, Manitoba, have been yielding an increasing output. The existence of gypsum deposits in British Columbia has been known for some years, and in 1911 some development work was done and the first shipments were made. A large proportion of the output of crude gypsum is shipped in lump form to calcining mills in the United States. About 9000 tons are pulverized for use as land plaster, and the remainder, about 15 per cent. of the total is calcined into plaster in Canada. The total production of crude gypsum in 1912 was 576,498 short tons, an increase of 11 per cent. over the output of 1911. The value of the products sold, including those ground and calcined, was $1,320,883. Exports amounted to 364,643 tons, valued at $423,208.

*India.*—An increase of about 50 per cent. in the output of gypsum occurred in 1911. Jamsar in Bikanir continues the largest producer; the Salt Range lost some of its importance; but in the Delhi district of the Punjab a remarkable increase is noted. The total output of the country in 1912 was 21,033 tons, compared with 9193 tons in 1911.

*England.*—The gypsum mines of England are situated principally in Nottinghamshire, Leicestershire and Derbyshire in the Midlands, and Yorkshire, Westmoreland and Cumberland, in the North; Nottinghamshire is the principle producer both in new mines and quarries, as it yields fully one-half of the total. From Chellaston about 6 miles south of Derby in Derbyshire, the gypsum bed follows an irregular winding southeast course, through Gotham, into Leicestershire, a distance of fully 30 miles, and is found in the Keuper marl. In this bed many mil-

lion tons are blocked out, and many more millions of tons have been proved by holes.

Not many of the mines or quarries are worked at high pressure, although there is no combination or amalgamation as to price or output and there is but little interchange of opinion between the owners or managers of the respective works. There is a bed of gypsum, from 4 to 12 miles northeast from Appleby, the capital of Westmoreland, but only one mine is actively worked, which has a mill for grinding the rock. This mill has been at work about 2 years, and is quite modern, and there is a good demand for the product. The other mines of this district send their crude gypsum by rail to glass manufacturers, and others.

FOREIGN COMMERCE OF GERMANY IN GYPSUM.

| Year. | Imports. | | Exports. | | Excess of Exports. | |
|---|---|---|---|---|---|---|
| | Metric Tons. | Value, Marks. | Metric Tons. | Value, Marks. | Metric Tons. | Value, Marks. |
| 1909.... | 11,285 | 294,000 | 63,228 | 1,688,000 | 51,943 | 1,394,000 |
| 1910.... | 10,873 | 284,000 | 89,660 | 1,847,000 | 78,787 | 1,563,000 |
| 1911.... | 11,973 | (e) 313,000 | 102,754 | (e) 2,117,000 | 90,781 | 1,804,000 |
| 1912.... | 10,628 | ..... | 108,137 | ..... | 97,509 | ..... |

(e) Estimated

*South Australia.*—The productive locality is in the southern portion of the Yorke Peninsula. The output of recent years has been valued as follows: 1910, £9000; 1911, £7275; 1912, £9000.

PRODUCTION OF CRUDE GYPSUM IN THE PRINCIPAL COUNTRIES. (a)
(In metric tons.)

| Year. | Algeria. (b) | Canada. | France. (b) | Germany. (c) | | Greece. | India. | United Kingdom. | United States. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Baden. | Bavaria. | | | | |
| 1898..... | 37,337 | 198,864 | 2,115,261 | 28,037 | 25,688 | 83 | 8,390 | 199,174 | 285,644 |
| 1899..... | 39,950 | 221,821 | 1,807,454 | 29,419 | 29,727 | 81 | 6,546 | 215,974 | 382,891 |
| 1900..... | 42,237 | 228,656 | 1,774,492 | 26,381 | 35,484 | 129 | 4,415 | 211,436 | 439,265 |
| 1901..... | 44,025 | 266,476 | 2,385,633 | 28,183 | 3,581 | 671 | (d) | 204,045 | 598,529 |
| 1902..... | 44,975 | 301,165 | 2,185,346 | 33,150 | 31,701 | *Nil.* | (d) | 228,264 | 740,906 |
| 1903..... | 41,550 | 285,242 | 1,998,804 | 29,423 | 30,894 | 94 | (d) | 223,426 | 945,285 |
| 1904..... | 48,375 | 309,133 | 1,957,802 | 26,984 | 22,766 | 393 | 3,937 | 237,749 | 853,546 |
| 1905..... | 34,743 | 395,341 | 1,378,145 | 28,823 | 46,247 | 185 | 4,877 | 259,596 | 982,626 |
| 1906..... | 27,950 | 378,904 | 1,377,429 | 25,643 | 50,763 | 70 | (e) 5,000 | 228,627 | 1,397,480 |
| 1907..... | 26,400 | 431,286 | 1,316,567 | 29,153 | 48,975 | 70 | (e) 5,000 | 239,285 | 1,564,061 |
| 1908..... | 25,500 | 346,436 | 1,750,562 | 35,217 | 51,314 | *Nil.* | (e) 5,000 | 231,980 | 1,694,155 |
| 1909..... | 36,250 | 398,290 | 1,655,672 | 36,621 | 51,630 | 191 | (e) 5,000 | 242,832 | (f) 2,042,286 |
| 1910..... | 60,625 | 481,941 | 1,980,804 | 41,078 | 54,397 | 249 | 6,678 | 259,648 | (f) 2,158,756 |
| 1911..... | 61,502 | 470,381 | 1,701,000 | 42,408 | 60,390 | 1,263 | 9,340 | 281,111 | (f) 2,112,770 |
| 1912..... | (d) | 523,114 | (d) | 51,777 | (d) | (d) | 21,369 | (e) 293,200 | (f) 2,269,290 |

(a) From official reports of the respective countries, except the statistics for the United States. (b) A part of the product is reported as plaster of Paris. In converting this into crude gypsum it has been assumed that the loss by calcination is 20 per cent. (c) Prussia is a large producer of gypsum, but there are no complete statistics available. The output in 1910 was 22,042 tons. (d) Statistics not yet available. (e) Estimated. (f) U. S. Geol. Surv.

## Manufacture of Plaster in Oklahoma[1]

By L. C. Snider

The manufacture of gypsum products, as practiced in the mills of Oklahoma, is very simple. Rock gypsum is quarried from the outcrop, broken into pieces easily handled by one man and is hauled to the mill or to the loading switch in wagons or in dump cars on a track. Gypsite is scooped up in drag scrapers and loaded into wagons or cars through a trap, or hauled directly to the mill in wheeled scrapers.

The gypsite is ready for the kettles without further preparation, but the rock gypsum must be crushed and ground. To effect this, the rock is passed through jaw crushers, and then through gyratory crushers, which reduce it to pieces less than 1 in. in diameter. This "gravel" is reduced to a fine powder in buhr mills, from which it is elevated into bins above the kettles.

The calcining kettles are cylindrical and are built of steel 3/8 in. thick. The ordinary sizes are 8 or 10 ft. in diameter and 8 ft. in depth. A vertical shaft passing down through the center of the kettle and driven by gearing at the top, is provided with arms which stir the gypsum during calcination. About 25 h.p. is required to drive the shaft of a 10-ft. kettle. Two or four flues about 1 ft. in diameter pass through the kettle horizontally, in order to secure a better distribution of the heat. The kettles are set like a boiler above a grate, and are surrounded by a wall 2 ft. thick built of fire-brick on the inside and common brick on the outside.

A 10-ft. kettle with 4 flues has a capacity of about 14 tons of plaster. The gypsite or ground rock is fed slowly into the kettles, 1 to 2 hours being required to fill a 14-ton kettle, depending on the condition of the material. While being filled the kettle is kept at a temperature of about 212° F. In about one hour after filling the kettle reaches a temperature of 230° F. and the mass begins to "boil," owing to the expulsion of the water of crystallization. At about 10° higher the mass settles down solid, but at 270° begins to boil violently again. At about 350° a gate near the bottom of the kettle is opened and the calcined gypsum flows rapidly into the "hot pit," which is built of fireproof material.

From this pit the material is elevated and screened through bolting cloth or fine wire screens. The portion passing through the screens is conveyed to bins above the mixers, while the coarse material is reground. Retarder and hair or wool fiber are added in the bins, and the whole

[1] *Eng. and Min. Journ.*, May 10, 1913.

passed down through the mixer, which feeds the plaster through openings at the bottom into sacks holding 100 lb. each.

*Cummer Continuous Process.*—In one mill, at Wilson, the Cummer continuous calcining process is used. In this process a rotary kiln is used in place of the kettles. The rock is crushed to 3/4-in. and stored in a bin over the feed spout of the rotary kiln. A mechanical feeder regularly feeds the crushed rock into the kiln. About 10 minutes is required for the material to pass through the kiln, and during its passage it reaches a temperature of 400 to 500° F. It is then fed into large bins built of brick, or of wood lined with brick, where it is allowed to remain 24 hours, during which time the excess heat carried over from the calciner is equally distributed through the material, which is thus uniformly calcined. The calcined gravel is then ground in buhr mills, screened, and mixed as in the kettle process. This process is based on the fact that heat in excess of that required for calcination, when applied in the presence of moisture, does not result in "dead burned" plaster. The gravel is steaming during its stay in the kiln and still contains moisture when placed in the bins. The advantages claimed for the process are two, the saving of fuel for calcination due to the continuous process, and the saving in power, since the rotary calciner is said to require less power than kettles of equal capacity, and much less power is required for grinding the clacined material from the bins than for grinding the raw gypsum as it comes from the quarry.

It is claimed that 70 lb. of good coal is required to calcine one ton of plaster in the rotary kiln, while 150 to 200 lb. per ton is required in the kettles. The power necessary for a rotary calciner of 200 tons capacity per 24 hours is said to be 12 h.p., while three 8-ft. kettles, of somewhat less capacity, require 40 h.p. or more for at least a portion of the time. The one mill in Oklahoma using this process has been in operation only a short time and the plaster has not yet been thoroughly tried out on the market. However, it is reported to be of good quality, and that made by this process in the East is said to be satisafctory.

*Cost of Erection and Operation.*—The cost of building and equipping a plaster mill will vary greatly with the type of mill and local conditions. A modern fireproof mill with three 10-ft. kettles can be built and equipped for from $65,000 to $70,000. The cost of manufacturing plaster also varies widely with local conditions, price of fuel, nature of material and kind of product. In one Oklahoma mill, where the conditions may be considered about average, the cost per ton for one month was $2.17 per ton of white (rock gypsum) plaster, and $2.01 for the dark plaster (40 per cent. gypsite). For another month the average cost per ton of the white material was $2.80 and of the dark, $2.57. The relative cost of

the different operations of manufacture may be stated as follows, for one of the two months mentioned above: Quarrying rock, $0.4515 per ton of rock; hauling rock, $0.2047 per ton of rock; gypsite $0.0873 per ton of raw material; retarder and fiber, $0.2668 per ton of plaster; fuel for powder and calcining, $0.312 per ton of plaster; milling (labor, lubricants, repairs, sundries), $1.0956 per ton of plaster. These costs are subject to wide variation, yet the figures given will furnish an approximate idea of the costs of manufacture with the kettle process. Data on the cost of manufacture by the rotary-calciner process are not available.

# IRON AND STEEL

By Frederick Hobart

The year 1912 will be memorable in the iron and steel industries for the rapid recovery from depression and a notable increase in production which carried the total outputs of nearly all forms to a higher level than had ever before been recorded. It will be remembered that in the first half of 1911 there was a period of marked depression and reaction from the overproduction of the preceding year, followed by a second half year of a very slow and halting recovery. About the beginning of 1912, however, it became apparent that the industrial demands of the country were reaching points which had never before been attained. In other words, the natural growth of the country had caught up to and was beginning to pass the expansion in productive capacity of the iron and steel works which occurred during and immediately after the boom of 1906–07.

The year opened rather quietly, but the period of expansion soon set in and continued gradually and with little halt until, in the second half, a production was demanded which exceeded that of any similar previous period in our history. The year closed with demand at its highest point; with furnaces and mills operating close to their full capacity and furnished with contracts and orders sufficient to carry them well through the first half of 1913, it is hardly necessary to say that accumulated stocks of material were almost completely exhausted.

Total forwardings of iron ore from the Lake district for the past 10 years are as follows in gross tons:

| | | | |
|---|---|---|---|
| 1903 | 24,308,510 | 1908 | 26,014,987 |
| 1904 | 21,849,401 | 1909 | 42,586,869 |
| 1905 | 34,384,116 | 1910 | 43,442,397 |
| 1906 | 38,565,762 | 1911 | 32,793,130 |
| 1907 | 42,266,268 | 1912 | 48,211,778 |

LAKE SUPERIOR ORE SHIPMENTS TO END OF 1912.
(In tons of 2240 lb.)

| Range. | Tons. | Per Cent. | Range. | Tons. | Per Cent. | Range. | Tons. | Per Cent. |
|---|---|---|---|---|---|---|---|---|
| Marquette | 103,332,139 | 18.0 | Gogebic | 72,735,653 | 12.6 | Mesabi | 279,046,135 | 48.6 |
| Menominee | 84,079,407 | 14.7 | Vermillion | 33,262,473 | 5.8 | Baraboo | 1,191,969 | 0.2 |
| | | | | | | Cuyuna | 452,542 | 0.1 |

PRODUCTION OF IRON ORE IN LAKE SUPERIOR DISTRICT.
(In tons of 2240 lb.)

| Year. | Tonnage. | Year. | Tonnage. | Year. | Tonnage. | Year. | Tonnage. | Year. | Tonnage. |
|---|---|---|---|---|---|---|---|---|---|
| 1855... | 1,449 | 1880.. | 1,948,334 | 1902.. | 27,562,566 | 1907.. | 42,266,668 | 1912.. | 48,211,778 |
| 1860... | 114,401 | 1885.. | 2,466,642 | 1903.. | 24,289,674 | 1908.. | 26,014,987 | ..... | ..... |
| 1865... | 193,758 | 1890.. | 9,003,725 | 1904.. | 21,822,839 | 1909.. | 42,586,869 | ..... | ..... |
| 1870... | 859,507 | 1895.. | 10,429,037 | 1905.. | 34,353,456 | 1910.. | 43,442,397 | ..... | ..... |
| 1875... | 881,166 | 1900.. | 19,059,393 | 1906.. | 38,522,239 | 1911.. | 32,793,120 | ..... | ..... |

SHIPMENTS OF IRON ORE FROM LAKE SUPERIOR DISTRICTS.
(In tons of 2240 lb.)

| Range. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|
| | Tons. | Tons. | Tons. | Tons. | Tons. | Tons. |
| Marquette..... | 4,388,073 | 2,414,632 | 4,256,172 | 4,392,726 | 2,833,116 | 4,203,308 |
| Menominee..... | 4,964,728 | 2,679,156 | 4,875,385 | 4,237,738 | 2,911,174 | 4,711,440 |
| Gogebic..... | 3,637,907 | 2,699,856 | 4,088,057 | 4,315,314 | 2,603,318 | 4,906,498 |
| Vermillion..... | 1,685,267 | 841,544 | 1,108,215 | 1,203,177 | 1,068,930 | 1,844,961 |
| Mesabi..... | 27,492,949 | 17,257,350 | 28,176,281 | 29,201,760 | 22,093,532 | 32,047,409 |
| Baraboo..... | 76,146 | 122,449 | 82,759 | 91,682 | 115,629 | 104,031 |
| Cuyuna..... | ..... | ..... | ..... | ..... | 147,431 | 305,111 |
| Total..... | 42,266,668 | 26,014,987 | 42,586,869 | 43,442,397 | 32,793,130 | 48,211,778 |

## Iron Ore

The production and consumption of iron ore for 3 years past are stated in the accompanying table. The slight increase in stocks reported for the year was mainly in that of Lake ore carried on the receiving docks and the increase was due, not to any lack of demand, but to scarcity of cars and of railroad facilities for shipment. There are no sufficient statistics from which to estimate the stocks in furnace yards, but the general testimony was to the effect that at the end of 1912 they certainly did not exceed those of a year previously; in fact many furnaces had their yards almost bare and were dependent on daily shipments.

Lake Superior ores continue to furnish by far the greater part of our raw material. We cannot vary greatly from the estimate which was held good for several years that over 80 per cent. of our pig iron is made from Lake Superior ores, which supply not only the furnaces of the Central West, but even to some extent find their way east of the Alleghenies.

The statistics of the Lake Superior ore shipments are carefully kept and generally accessible. Full particulars of the movement of that ore for 3 years past are given in the accompanying tables.

The iron mines of the South are for the most part closely controlled by the manufacturing companies and the production is generally proportioned rather closely to the activity of the furnaces, as it is not the usual custom to carry any large stocks. Many improvements have been made at the Southern mines, especially in Alabama, in the way of mining and

preparation of ores. Some new mines have been opened and, toward the close of the year, arrangements were made to test several of the large brown-ore mines in the Birmingham district by boring and sinking shafts in order to determine whether the deposits extend to depths below the present workings.

IRON ORE MINED AND CONSUMED IN THE UNITED STATES.
(In tons of 2240 lb.)

| District. | 1906. | 1907. | 1908. | 1909(a). | 1910(a). | (1911(a). | 1912(a). |
|---|---|---|---|---|---|---|---|
| Lake Superior.... | 38,522,129 | 42,245,070 | 26,014,987 | 42,586,869 | 42,442,397 | 32,743,190 | 48,410,477 |
| Southern States.. | 7,450,000 | 7,585,000 | 5,900,000 | 7,350,000 | 7,500,000 | 6,425,000 | 7,590,000 |
| Other States..... | 3,265,000 | 3,125,000 | 1,875,000 | 3,150,000 | 3,325,000 | 2,660,000 | 3,485,000 |
| Total..... | 49,237,129 | 52,955,070 | 33,789,987 | 53,086,869 | 53,267,397 | 41,878,190 | 59,485,477 |
| Add decrease in stocks..... | ..... | ..... | ..... | ..... | ..... | 650,000 | ..... |
| Add imports..... | 1,060,390 | 1,229,168 | 776,898 | 1,696,411 | 2,591,031 | 1,811,732 | 2,104,576 |
| Total..... | 50,297,519 | 54,284,238 | 34,566,885 | 54,783,280 | 55,858,428 | 44,339,922 | 61,590,053 |
| Increase in stocks | ..... | 3,750,000 | 750,000 | 521,000 | 950,000 | ..... | 200,000 |
| Deduct exports.. | 265,240 | 278,208 | 309,099 | 455,932 | 644,875 | 768,386 | 1,195,743 |
| Total consumption..... | 50,032,279 | 50,256,030 | 33,507,786 | 53,806,304 | 53,263,553 | 43,571,536 | 60,194,310 |

(a) From *Eng. and Min. Journ.*

RECEIPTS AND STOCKS AT LAKE ERIE PORTS.
(In tons of 2240 lb.)

| Ports. | Receipts. | | | Stocks. | | |
|---|---|---|---|---|---|---|
| | 1909. | 1910. | 1911(a). | 1909. | 1910. | 1911(a). |
| Toledo..... | 1,374,224 | 1,225,202 | 493,345 | 332,456 | 433,215 | 661,382 |
| Sandusky..... | 11,088 | ..... | ..... | 39,557 | 17,728 | 2,471 |
| Huron..... | 243,082 | 197,951 | 223,947 | 477,333 | 375,118 | 344,371 |
| Lorain..... | 2,796,856 | 2,884,738 | 2,937,605 | 407,129 | 259,448 | 314,321 |
| Cleveland..... | 6,051,342 | 5,800,501 | 4,584,211 | 1,547,142 | 1,638,795 | 1,589,491 |
| Fairport..... | 1,734,277 | 1,516,434 | 666,365 | 867,640 | 839,970 | 636,566 |
| Ashtabula..... | 8,056,941 | 9,620,638 | 6,359,131 | 2,594,359 | 3,287,816 | 3,295,862 |
| Conneaut..... | 7,007,834 | 6,309,548 | 6,931,278 | 1,411,002 | 1,329,997 | 1,237,573 |
| Erie..... | 1,235,057 | 942,592 | 289,400 | 788,046 | 792,011 | 636,274 |
| Buffalo..... | 5,002,235 | 4,704,439 | 2,802,976 | 501,125 | 452,783 | 413,353 |
| Detroit..... | 159,889 | 296 412 | 243,292 | ..... | ..... | ..... |
| Total..... | 33,672,825 | 33,498,455 | 25,531,550 | 8,965,789 | 9,426,681 | 9,131,664 |

In the Eastern states the demand for iron ore led to increased activity in the old mines of New York, New Jersey and Pennsylvania; several new mines were opened and some old mines reopened, while some advances were made in the way of treating the ore by concentration and otherwise to make it more available for furnaces. The principal activity was in the Lake Champlain district of New York, where the chief operators are Witherbee, Sherman & Co., who have, for a number of years, controlled the iron mines in the neighborhood of Port Henry and Mineville. The Bethlehem Steel Co. is also operating the Cheever mine near Port Henry.

The Adirondack district in New York has been furnishing an increased quantity of ores at Dannemora and elsewhere, while operations have also been going on in the Clinton ore deposits of Wayne County. In the Hudson River district the Forest of Dean mine, near Fort Montgomery, has been operated steadily and is planning new equipment and development. Arrangements have been made to reopen the old Croton mines near Dover Plains, where a considerable ore-body has been proved by drilling, and a magnetic treatment plant is being installed. No new mines have been opened in New Jersey, but a number of older mines have been actively operated.

An iron-ore development from which large shipments are expected was opened during the year in eastern Texas. Shipments from this deposit will be made chiefly to Baltimore and Philadelphia for use in Eastern furnaces. At the opening of 1912 a larger business was anticipated in imported ores, but a serious check was given to the business by the rapid advance in ocean freights, which in the latter part of the year reached a level which made the cost of Spanish and Swedish ores almost prohibitive, so that probably only a small portion of our ore supply will come from those countries in 1913. The Cuban iron mines are principally owned by American steel companies, which control their own carrying vessels and use the ore in their own works, very little Cuban ore being sold in the open market. There are also likely to be some imports in 1913 from the Wabana mines in Newfoundland, although the high cost of ocean tonnage will affect that business also.

The sources of the imported ores are stated in the following table, as reported by the U. S. Department of Commerce and Labor:

IMPORTS OF IRON ORES INTO THE UNITED STATES.
(In tons of 2240 lb.)

| Country. | 1910. | 1911. | 1912. |
|---|---|---|---|
| Canada | 89,305 | 50,480 | 106,675 |
| Cuba | 1,451,096 | 1,147,879 | 1,398,593 |
| Newfoundland and Labrador | 214,706 | 174,853 | 145,355 |
| Spain | 439,868 | 194,965 | 92,061 |
| Sweden | 259,911 | 219,238 | 333,863 |
| Other countries | 136,145 | 24,317 | 28,029 |
| Totals | 2,591,031 | 1,811,732 | 2,104,576 |

Exports of iron ores, amounting to 1,195,742 long tons in 1912, consisted mainly of Lake Superior ore sent to Canadian furnaces.

As is well known, the prices of Lake Superior iron ore are usually fixed for the season early in the year, and those prices for the season of 1912 were as follows: Old Range bessemer, $3.75 per ton; Mesabi bessemer, $3.50; Old Range non-bessemer, $3; Mesabi non-bessemer, $2.85. These

prices are all f.o.b. docks at Lake Erie ports, the basis being 55 per cent. iron and under 0.45 phosphorus for bessemer ores; 51.5 iron for non-bessemers. The cost of these ores for furnaces is increased by the freight from the Lake port to the furnace, varying, of course, according to its location. During the year the Interstate Commerce Commission ordered a reduction from 80 cents to 60 cents in the rate charged for carrying ore from the mines to Lake Superior ports.

Toward the close of the year it became apparent that there would be an increase in rates for 1913 and these were fixed at an unusually early date, November instead of January or February, as has been common. The new rates were as follows, on the same basis of contracts as for 1912: Old Range bessemer, $4.40; Mesabi bessemer, $4.15; Old Range non-bessemer, $3.60; Mesabi non-bessemer, $3.40 per ton. This increase is equivalent to an advance of about $1 per ton in the cost of pig-iron.

Rates on Eastern iron ores also advanced during the year. It is impossible to give detailed rates, but in a general way it may be said that it was approximately from about 6 3/4 to 7 3/4 cents per unit of iron at mines, while for foreign ores the advance has been from 7 to 8 1/4 cents per unit of iron at landing port.

## Iron Ores in the United States

*The Lake Superior Region* (By Dwight E. Woodbridge).—Iron-ore shipments from the Lake Superior region were heavier in 1912 than ever before; this was in spite of a rather dull-looking year at its outset. The record so set was 48,211,778 gross tons, which compares with 32,793,130 tons for the preceding year and with 43,442,869 tons for 1910, which was the most notable year up to the present. Total water shipments for the year were 47,435,771 gross tons, as against 32,130,411 tons for the preceding season of navigation. These figures are exclusive of Canadian shipments, which reached a total of 100,000 tons for 1912. The proportion of shipments by the mines of the U. S. Steel Corporation was a little less than usual and amounted to 49.5 per cent. of the whole. In 1911 the corresponding proportion was 52.7 per cent. of all. This diminution is somewhat remarkable, as it comes in spite of an enormous tonnage mined from Great Northern leases by the Steel Corporation.

Eleven mines around the Lake produced more than 1,000,000 tons each; two of these are on old ranges, and two are not the property of the Steel Corporation. These eleven averaged 1,550,000 each, and were led in individual quantities by the Hull, 2,232,112 tons; the Leonard, 2,198,119; and the Canisteo, 2,099,880 tons.

The season was one of low mining costs, low freights both by rail and

lake, few losses and a constantly accelerating demand. Labor was fairly plenty, until toward the close of the year when the war of the Balkan allies drew many foreigners home. The institution of safety devices at mines reduced the number and extent of personal injuries among miners. As it was the first year in which there had been a general tendency toward safety precautions this result is most gratifying. In Minnesota fatalities were 16 per cent. fewer in 1911, although there was one very unusual accident in which 15 men lost their lives. Non-fatal accidents dropped off 35 per cent., in spite of the fact that more men were engaged in mining.

The fleet of great-lake ships, though increased but slightly over 1911 and though called upon to move a greater volume of grain and coal than ever before, was ample to care for the enormous traffic in ore, and can easily handle, without additions, many more million tons than it was called on to deliver during the year. As a result, the construction of new ships is slow. With the exception of two for the Steel Corporation and a few others, the fleet for freight traffic will be unchanged in 1913. Ore prices will be higher by about 65 cents a ton and lake freights will advance by 5 cents.

The Steel Corporation showed great activity in handling ore from its Great Northern lease, which is soon to expire and under which it had paid nearly $3,000,000 in advance royalties. It took out, not alone the 4,500,000 tons of the year's minimum, but all the accrued deficiencies, thus ending the year on an even keel, so far as these advance royalties were concerned. The total shipments out of mines in which the Great Northern has all or a part interest amounted to about 9,000,000 tons, but interests in some of the mines shipping this are owned by others than the Great Northern and its associated lessors. Shipments to be credited to the lease were about 7,000,000 tons. If this rate can be maintained for the two remaining seasons, gross shipments of the term will exceed considerably the minimum of the leasehold.

Explorations in 1912 were chiefly confined to the Cuyuna and Menominee ranges, with some less important work on the Vermilion and Mesabi. In the 8 or 9 years since the Cuyuna was discovered no single 12 months witnessed as great development. The nature of the district is better understood than in earlier years. It is difficult to state the tonnage of ore found in 1912, but it is safe to say that there now exist in the Cuyuna more than 250,000,000 tons of ore, in addition to which are far greater quantities of ore material too low to be mineable at present or without treatment. Though shipments from the Cuyuna for the year were but 305,000 tons, they bid fair to be very much greater the coming summer. Opened mines are the Kennedy (Sec. 30, 47–28), the Meacham,

Thompson and Armour No. 2 (all in Sec. 11, 46–29), the Armour No. 1 (Sec. 10, 46–29), the Cuyuna Mille Lacs (Sec. 3, 46–29), the Adams (Sec. 30, 46–28), and the Barrows (Sec. 30, 44–21). All these will ship the coming season. In addition to them is the Pennington mine of Tod Stambaugh & Co. in Sec. 10, 46–29, and the Carlson-Williams property in Sec. 18, same township. The peculiarity of these last-named two is that they are to be stripped for open-cut mining.

At the Pennington mine, the removal of 1,000,000 yd. of overburden will expose for mining a like tonnage that can be taken by steam shovel, and a further million tons that is available for milling. The royalty on this property exceeds any other in the district, being at the rate of 80 cents per ton for the open pit ore.

Just now these figures seem to be very high. Stripping at the Pennington mine is to be done by steam shovel; at the Carlson property it is by hydraulic giants. These loosen the material, which is afterward handled to a slope by a centrifugal pump. A similar process is to be undertaken at another property in the same neighborhood.

In a certain restricted district of the Cuyuna, centering about Sec. 3, 46–29, considerable deposits of manganiferous iron ore have been found and opened by several companies, one of which has commenced shipment of some small orders. It is claimed that these shipments have been at considerable profit to the mining company, and that orders for a large amount have been received as the result. It is difficult, as yet, to gage the value of these discoveries of manganese. The Cuyuna Mille Lacs is said to have shipped five carloads averaging 31 per cent. Mn and 30 per cent. Fe. The manganiferous district as so far determined includes parts of sections 3, 4, 10 and 11, townships 46–29, and of sections 22, 33, and 34, township 47–29. A little ore running better than 50 per cent. has been found in section 33, 47–29.

In anticipation of a greater business from the Cuyuna the Soo Line is extending its shipping piers to double its present size, and the Northern Pacific is preparing to construct a steel and concrete pier similar, in all but size, to those of the Great Northern road. The Northern Pacific has grouped a large acreage of Cuyuna lands, on some of which it has been paying royalties for years. It is possible that Cuyuna shipments in 1913 may approach 1,000,000 tons.

Explorations on the Vermilion range seem to have demonstrated the probability of two or three mines. The section 30 property has been very materially increased in importance by the year's work, and promises to become a great mine. For many years the Vermilion range has been a one-company district, all its mines having been the properties of the Oliver Iron Mining Co. But this is changed. Of shipments of 1,844,981 tons

for the last year, 230,744 tons were from independent shippers, the Section 30 company,157, 344 tons; the Chandler, 73,370, and the White Iron Lake Co., 30 tons. During 1913, the Section 30 company may double its 1912 shipments and the favorable explorations referred to above may produce a little ore. Both are arranging for railroad connection and both have a little ore on stockpile.

There was much activity in 1912 in the Menominee district. In the Mastodon field, at Palatka, in the Norway section, near Iron River, at Iron Mountain, and elsewhere, there was much development in the way of opening new mines and reworking old shafts and old time mines that had been idle for a long time. The district is looking exceptionally well, and will increase its capacity for production many years. At present it is probable that the Menominee district is by far the most favorable field for exploration around Lake Superior. A number of large deposits have been opened during the past year and the tonnage of the district will be increased in 1913.

In the Marquette district the Cascade section was unusually active, and in addition to the enormous holdings of low-grade ores existing there, good ores are being found and opened for mining on a large scale. In the vicinity of Gwinn and west of Negaunee the Cleveland-Cliffs company added to its operations. Its North Lake mine was developed to an important property, and its Gwinn properties are now beginning to show that they are both big and good. Its Maas mine is increasing and its Negaunee was re-equipped.

There is but little to be said as to the Gogebic district. By the work of R. B. Whiteside and others the productive portion of the range was lengthened somewhat, these interests now being at work sinking a working shaft some distance to the east of Sunday Lake. The Cleveland-Cliffs company abandoned its Ashland mine lease, held for the last 10 years, and the fee owners are again at work. Considerable ore is known to remain in the mine, but it is of a grade that will not stand high royalty rates. Norris-Aurora and Newport made great records for the year, and the district in general is in most excellent condition, with its many fine steel footwall shafts and its fine surface and underground improvements. At Wakefield ore has been found in a faulted section of the range and one mine is under development.

Developments of 1912 in the Mesabi district tended toward the increase in the amount of ore to become available for purchase by independent furnace interests. Exploration was slack and but little new tonnage was developed. However, two great independent mining companies began business, neither with furnace affiliations, and each with a vast tonnage of unopened ores of varying grades, each intending to sell its

product on the open market. This is a development of the widest importance. It will relieve the furnace operator, who has not sufficient ore of his own, of the fear that he will be crowded out of the business, and it will have an important bearing on prices of Lake Superior iron ores. These two companies are the Great Northern Ore Properties and the Sargent Land Co. The latter owns a very important share of the ores that were included in the Great Northern lease to the U. S. Steel Corporation, now abrogated. The Great Northern Ore Properties is opening three surface mines of good grades of ores, situated in townships 58–19, 58–20, and 57–21, and is to open others, part surface and part underground. It is the intention to be able to mine and sell not less than 3,000,000 tons of ore per year, commencing with 1915. The Sargent Land Co. owns what are known as the Pillsbury, Bennett & Longyear lands, on the westerly part of the Mesabi, and it is now opening a large property in Sec. 24, T. 57–22. This will be stripped for steam-shovel mining and a shaft will be sunk to handle the bulk of the deposit, which is one of the great ore-bodies of the Mesabi. The same interests control a great deposit of good ore in 58–15, as well as large tracts of land that have not yet been taken out of the Great Northern leasehold. As the Cascade Mining Co., they also have an important mine on the Marquette range that is being opened by the sinking of a large shaft which must go down nearly 900 ft. to the ore. They also control properties near Crystal Falls that are under preliminary development. This company can be as large a shipper as the Great Northern and will be able to produce ores of varying characteristics. The important changes during 1912 included the reduction of freight rates on ore from the mines to the shipping ports, by the various railways operating there. This was from 80 to 60 cents per ton and covers all shipments from the Mesabi. This reduction serves to decrease the differential against the Mesabi ores from 25 cents, as formerly, to 5 cents this year. There is little doubt that this differential will be wiped out, as will that against non-bessemer ores.

*Grade of Lake Superior Ores.*—A series of tables compiled by W. L. Tinker, secretary of the Lake Superior Iron Ore Association, shows the iron contents of ores from the different ranges over a series of years, from which we select the following:

| Ranges. | 1902. | 1906. | 1911. | 1912. |
|---|---|---|---|---|
| Marquette: | | | | |
| Bessemer, iron | 58.2631 | 56.5151 | 54.0668 | 54.4180 |
| Bessemer, phosphorus | 0.0424 | 0.0485 | 0.0375 | 0.0403 |
| Non-bessemer, iron | 55.1032 | 53.9861 | 52.4757 | 52.7308 |
| Menominee: | | | | |
| Bessemer, iron | 57.7141 | 55.8979 | 54.5578 | 55.2117 |
| Bessemer, phosphorus | 0.0167 | 0.0363 | 0.0330 | 0.0252 |
| Non-bessemer, iron | 54.1020 | 52.2508 | 51.4315 | 51.0527 |

| Ranges. | 1902. | 1906. | 1911. | 1912. |
|---|---|---|---|---|
| Gogebic: | | | | |
| Bessemer, iron | 55.7324 | 54.2732 | 54.5312 | 54.2389 |
| Bessemer, phosphorus | 0.0418 | 0.0416 | 0.0400 | 0.0416 |
| Non-bessemer, iron | 53.7872 | 51.8580 | 52.9294 | 53.2912 |
| Vermilion: | | | | |
| Bessemer, iron | 61.5522 | 60.1254 | 59.5940 | 59.3095 |
| Bessemer, phosphorus | 0.0398 | 0.0393 | 0.0384 | 0.0385 |
| Non-bessemer, iron | 61.9984 | 64.5798 | 59.5984 | 58.7775 |
| Mesabi: | | | | |
| Bessemer, iron | 56.6690 | 54.6196 | 52.9224 | 53.2572 |
| Bessemer, phosphorus | 0.0395 | 0.0441 | 0.0462 | 0.0466 |
| Non-bessemer, iron | 53.5531 | 50.8088 | 50.4934 | 49.4920 |

The main point to be noticed in these tables is that the decline in iron contents of the ores, which has been progressive for several years, was apparently arrested in 1912. For nearly all the ranges there was a slight increase over 1911, or at least no decrease. Another notable point is the decrease in the proportion of bessemer ores to the total, which has taken place in the last 10 years. On the Marquette range the decline in the proportion of bessemer ores was 29.9 per cent. in 1902 to 15 per cent. in 1912; on the Menominee from 2.8 to 2.5 per cent; on the Gogebic from 87.5 to 64.1 per cent.; on the Vermilion from 80.1 to 74.9 per cent.; on the Mesabi from 80.6 to 45.3 per cent. The Vermilion range has always shown the highest percentage of bessemer ores.

*The Southern Districts* (By D. E. Woodbridge).—A most gratifying result has been accomplished in the Birmingham district of Alabama by the drilling of a deep borehole so far back from the outcrop of the Clinton ores there that their probable tonnage of good grades is, perhaps, doubled. That it is very greatly increased no one will gainsay. It is safe enough to say that the available tonnage of red ores in the immediate vicinity of Bessemer and Birmingham, extending under Shades valley to a depth not at all unfavorable for mining, amounts to materially more than 1,000,000,000 tons. It makes little difference whether or not one estimates either under or over this figure, for the controlling factors in the district are not iron ore nor coal, but labor, transportation and population. The reserves are sufficient to last for a great length of time. There has been no advance in the use of the gray ores of the South, nor has there been much activity in the brown ores, the tonnages of both of which varieties are vast.

In Texas the ores of the northeastern part of the state have come into use, and shipments are being made to Port Bolivar, thence to Atlantic ports. It is some 300 miles from the most distant of these mining developments to Port Bolivar, so that the question of freights is an important one. A very considerable tonnage of medium-grade ores has been developed and some heavy consumers are interested in the district.

Reports have been made of the discovery of ores in northern Mississippi, but these have received scant attention. Not much is known of the probabilities in that region.

## New Iron Ore Resources

*Texas.*—During the mapping of the Llano and Burnet quadrangle, 32 distinct occurrences of iron ore were studied. The most important, the Olive iron ore property, located 6 miles northeast of Llano, has been more extensively developed than others, and was opened by shaft in 1892. The deposit is a tabular body 2 to 8 ft. thick with no outcrops. Analysis of the ore is as follows:

| | |
|---|---|
| Iron | 57.80 to 54.35 per cent. |
| Silica | 8.40 to 10.16 per cent. |
| Sulphur | 0.28 to 0.55 per cent. |
| Phosphorus | Trace to 0.021 per cent. |

The Iron Mountain prospect is 12 miles northwest of Llano. The surface outcrop has a length of about 114 ft. and a width of 22 ft. at its center, narrowing to 6 ft. at the southeast end. The ore-body would appear to be a vertical mass of pure magnetite.

The Bader tract is about nine miles west of Llano. Iron ore has been found at several places along a zone trending northwest, and about 500 ft. wide and 700 ft. long.

Abundant float of pure magnetite occurs west of Click. The float comes from a contact between the Hickory sandstone and the ancient crystalline schists.

*Wisconsin.*—A great deal of quiet interest is felt in explorations in northern Wisconsin. The old geologic maps give the whole of northern Wisconsin as pre-Cambrian granite, and the mining men of the Lake Superior ranges have always held the belief that the ore stopped at the Wisconsin state boundary. A couple of years ago Mr. Carpenter, of Chicago, and associates, after having some careful magnetic work done, entered the field and purchased mineral rights to large areas of land, which they are now exploring.

The geological facts are these. The Huronian sedimentaries unquestionably occupy large areas in northern Wisconsin, as shown by this magnetic work, and by other things which the older mapping did not take into account. The glacial drift is thick over all this region and there are probably no rock outcrops. What few exist are granite and quartzite, the most resistant rocks, as would be expected. The softer iron-bearing series has been more deeply eroded and more deeply covered by the glacial drift, so that it is known only by the presence of magnetic attractions.

Over the large amount of territory in which these magnetic attractions exist it is quite possible that northern Wisconsin may ultimately have as many large iron-producing ranges as northern Michigan, and that at a not very distant time.

The State Geological Survey had several parties in the field in the summer of 1913 beginning magnetic and geologic surveys of the northern part of the state. The area is so large that even with a large sum of money available for the purpose it will take a number of years to cover the whole area.

A new discovery of iron ore in southwestern Wisconsin is reported. The district, which lies in Vernon and Crawford Counties, was very thoroughly covered by the former geological survey of Wisconsin in 1873, and the deposits were explored in many different localities at several periods from 1840 on. So far as known they are derived from the oxidation of pyrite in more or less heavily pyritic beds near the top of the Potsdam sandstone. While the surface extent is sometimes quite large, the thickness is not known to be more than a few feet, except in isolated small areas, where reports of as much as 40 ft. have sometimes been made; these reports, however, are no more than gossip, not the result of reliable work, and not accompanied by assays. It is reported that one of the large companies operating in the Lake Superior district is now planning to carry on some drilling operations, to determine the character and extent of these ores.

## Pig Iron

The production of pig iron, which in 1911 was at the rate of about 1,950,000 tons, and did not vary greatly through that year, commenced to expand early in 1912 and for the first half of the year reached a total of 14,072,274 tons according to the report of the American Iron & Steel Association. During the second half of the year production continued to increase, giving a total for that half of 15,654,663 tons, making a total for the year of 29,726,937 tons of pig iron in 1912. It is probable that the total would have gone over 30,000,000 tons for the year had not a scarcity of coke developed in the last 3 months, which prevented some furnaces from blowing in, and also limited the activity of others in blast.

PRODUCTION OF PIG IRON BY STATES.
(In tons of 2240 lb.)

| tes. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|
| usetts | | | | | | | |
| ecticut.. | 20,239 | 19,119 | 13,794 | 18,388 | 16,582 | 9,649 | 17,366 |
| k. ..... | 1,552,659 | 1,659,752 | 1,019,425 | 1,733,675 | 1,938,407 | 1,562,756 | 1,939,231 |
| ey. .... | 379,390 | 373,189 | 225,372 | 294,474 | 264,781 | 40,663 | 36,876 |
| ania ... | 11,247,869 | 11,348,549 | 6,987,191 | 10,918,824 | 11,272,323 | 9,807,073 | 12,552,131 |
| ..... | 386,709 | 411,833 | 183,502 | 286,856 | 326,214 | 255,816 | 219,546 |
| ..... | 483,525 | 478,771 | 320,458 | 391,134 | 444,976 | 293,642 | 256,167 |
| ..... | 1,674,848 | 1,686,674 | 1,397,014 | 1,763,617 | 1,939,147 | 1,712,211 | 1,862,681 |
| Geo. & | | | | | | | |
| ..... | 92,599 | 55,825 | 24,345 | 26,072 | 14,725 | 1,200 | *Nil.* |
| ginia. .. | 304,534 | 291,066 | 65,551 | 228,282 | 174,661 | 291,472 | 274,360 |
| /..... | 98,127 | 127,946 | 45,096 | 86,371 | 100,509 | 95,202 | 68,760 |
| ..... | 426,874 | 393,106 | 290,826 | 333,845 | 397,569 | 324,648 | 338,238 |
| ..... | 5,327,133 | 5,250,687 | 2,861,325 | 5,551,545 | 5,752,112 | 5,310,506 | 6,802,493 |
| ..... | 2,156,866 | 2,457,768 | 1,691,944 | 2,467,155 | 2,675,646 | 2,108,002 | 2,887,359 |
| ..... | 369,456 | (a)436,507 | (a)348,096 | (a)964,289 | (a)1,250,103 | 1,163,932 | (a)1,770,628 |
| & Minn | 373,323 | 322,083 | 148,938 | 348,177 | 307,200 | 276,807 | 303,370 |
| ss. River | 413,040 | 468,486 | 313,071 | 382,767 | 428,612 | 395,968 | 397,731 |
| ..... | 25,307,191 | 25,781,361 | 15,936,018 | 25,795,471 | 27,303,567 | 23,649,547 | 29,726,937 |

ncludes Indiana.

PIG IRON PRODUCTION OF THE UNITED STATES.
(In tons of 2240 lb.)

| f Iron. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|
| and forge | 5,714,492 | 6,397,777 | 4,307,734 | 6,386,833 | 6,352,379 | 5,256,830 | (a)6,076,287 |
| pig .... | 13,840,518 | 13,231,620 | 7,216,976 | 10,557,370 | 11,245,642 | 9,409,303 | 11,664,015 |
| ..... | 5,018,674 | 5,375,219 | 4,010,144 | 8,250,225 | 9,084,608 | 8,520,020 | 11,417,886 |
| ..... | 433,007 | 437,397 | 249,146 | 376,003 | 396,507 | 278,676 | 347,025 |
| nd ferro. | 300,500 | 339,348 | 152,018 | 225,040 | 224,431 | 184,718 | 221,724 |
| ..... | 25,307,191 | 25,781,361 | 15,936,018 | 25,795,471 | 27,303,567 | 23,649,547 | 29,726,937 |

ncludes "Foundry and ferro-silicon;" "Malleable Bessemer;" "Forge Pig-iron;" and "White led, direct castings, etc.;" excluding charcoal iron.

PRODUCTION OF PIG IRON BY DISTRICTS.
(In tons of 2240 lb.)

| | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|
| nd, N. Y. and N. J.. | 2,052,060 | 1,258,661 | 2,046,537 | 2,219,770 | 1,613,068 | 1,993,473 |
| ania. ..... | 11,348,549 | 6,987,191 | 10,918,824 | 11,272,323 | 9,807,073 | 12,552,131 |
| , Mich., Wis. & Minn. | 8,467,045 | 5,050,303 | 9,331,166 | 9,986,061 | 8,859,247 | 11,763,850 |
| i ..... | 411,833 | 183,502 | 286,856 | 326,214 | 255,816 | 219,546 |
| States..... | 3,033,388 | 2,143,290 | 2,829,321 | 3,071,587 | 2,718,375 | 2,800,206 |
| the Mississippi..... | 468,486 | 313,071 | 382,767 | 428,612 | 395,968 | 397,731 |
| ..... | 25,781,361 | 15,936,018 | 25,795,471 | 27,303,567 | 23,649,547 | 29,726,937 |

PIG IRON PRODUCTION ACCORDING TO THE FUEL USED.
(In tons of 2240 lb.)

| Used. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|
| ..... | 23,313,498 | 23,972,410 | 15,331,863 | 24,721,037 | 26,257,978 | 23,141,296 | 29,132,733 |
| te & coke. | 1,535,614 | 1,335,286 | 318,741 | 682,383 | 628,579 | 212,548 | 236,467 |
| te alone... | 25,072 | 36,268 | 36,268 | 16,048 | 20,503 | 17,027 | 10,712 |
| ..... & coke.. | 433,007 | (b)437,397 | (b)249,146 | (b)376,003 | 396,507 | 278,676 | 347,025 |
| ..... | 25,307,191 | 25,781,361 | 15,936,018 | 25,795,471 | 27,303,567 | 23,649,547 | 29,726,937 |

Under coke furnaces are included the very few which use raw bituminous coal. It may be that 99 per cent. of this class of iron was made with coke. (b) Includes a small quantity the electric furnace.

The accompanying table, is compiled from the records of the American Iron and Steel Association.

PIG IRON PRODUCTION FOR 100 YEARS.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1820 | 20,000 | 1859 | 750,650 | 1878 | 2,301,215 | 1897 | 9,652,680 |
| 1828 | 130,000 | 1860 | 821,223 | 1879 | 2,741,853 | 1898 | 11,773,934 |
| 1829 | 142,000 | 1861 | 653,164 | 1880 | 3,835,191 | 1899 | 13,620,703 |
| 1830 | 165,000 | 1862 | 703,270 | 1881 | 4,144,254 | 1900 | 13,789,242 |
| 1831 | 191,000 | 1863 | 846,075 | 1882 | 4,623,323 | 1901 | 15,878,354 |
| 1832 | 200,000 | 1864 | 1,014,282 | 1883 | 4,595,510 | 1902 | 17,821,307 |
| 1840 | 286,903 | 1865 | 831,770 | 1884 | 4,097,868 | 1903 | 18,009,252 |
| 1842 | 215,000 | 1866 | 1,205,663 | 1885 | 4,044,526 | 1904 | 16,497,033 |
| 1846 | 765,000 | 1867 | 1,305,023 | 1886 | 5,683,329 | 1905 | 22,992,380 |
| 1847 | 800,000 | 1868 | 1,431,250 | 1887 | 6,417,148 | 1906 | 25,307,191 |
| 1848 | 800,000 | 1869 | 1,711,287 | 1888 | 6,489,738 | 1907 | 25,781,361 |
| 1849 | 650,000 | 1870 | 1,665,179 | 1889 | 7,603,642 | 1908 | 15,936,018 |
| 1850 | 563,755 | 1871 | 1,706,793 | 1890 | 9,202,703 | 1909 | 25,795,471 |
| 1852 | 500,000 | 1872 | 2,548,713 | 1891 | 8,279,870 | 1910 | 27,303,567 |
| 1854 | 657,337 | 1873 | 2,560,963 | 1892 | 9,157,000 | 1911 | 23,649,547 |
| 1855 | 700,159 | 1874 | 2,401,262 | 1893 | 7,124,502 | 1912 | 29,726,937 |
| 1856 | 788,515 | 1875 | 2,023,733 | 1894 | 6,657,388 | ..... | ..... |
| 1857 | 712,640 | 1876 | 1,868,961 | 1895 | 9,446,308 | ..... | ..... |
| 1858 | 629,548 | 1877 | 2,066,594 | 1896 | 8,623,127 | ..... | ..... |

Two years ago we reported a large increase in the stocks of pig iron unsold or unused at furnaces. In 1911 a substantial decrease in these stocks was secured, and in 1912 they were substantially absorbed. At the close of the year there were, undoubtedly, no stocks of unused or unsold iron at furnaces beyond those which it is always necessary to carry as a balance and to prevent an absolute reliance upon daily production.

The consumption for 1912 was approximately 703 lb. per capita, being 109 lb. more than in the preceding year. In this computation, however, no account is made of the products of pig iron exported in the form of finished iron and steel.

CONSUMPTION OF PIG IRON IN THE UNITED STATES.
(In tons of 2240 lb.)

| | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|
| Production | 15,936,018 | 25,795,471 | 27,303,567 | 23,649,547 | 29,726,937 |
| Imports | 92,202 | 174,988 | 237,233 | 148,459 | 129,325 |
| Decrease in stocks | ..... | ..... | ..... | 1,250,000 | 600,000 |
| Total | 16,028,220 | 25,970,459 | 27,540,800 | 25,048,006 | 30,456,262 |
| Exports | 46,696 | 61,999 | 127,964 | 122,636 | 277,763 |
| Increase in stocks | ..... | ..... | 1,700,000 | ..... | ..... |
| Approximate consumption | 15,981,524 | 25,908,460 | 25,712,836 | 24,925,370 | 30,178,499 |

## Imports and Exports

The accompanying tables show the values and—as far as possible the quantities—of the imports and exports of the United States, as reported by the Department of Commerce.

UNITED STATES EXPORTS OF DOMESTIC IRON AND STEEL.
(In tons of 2240 lb.)

| | 1905. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|---|
| Pig iron | 49,221 | 83,317 | 73,844 | 46,696 | 61,999 | 127,385 | 120,799 | 272,676 |
| Billets, blooms, etc. | 237,638 | 192,616 | 79,991 | 112,177 | 104,862 | 58,230 | 234,767 | 295,818 |
| Bars | 51,870 | 88,102 | 98,654 | 46,103 | 87,960 | 125,606 | 141,033 | 230,139 |
| Rails | 295,023 | 328,036 | 338,906 | 196,510 | 299,540 | 353,180 | 420,874 | 446,473 |
| Sheets and plates | 75,034 | 110,654 | 122,696 | 104,993 | 180,048 | 274,516 | 372,373 | 546,968 |
| Structural steel | 83,193 | 112,555 | 138,442 | 116,878 | 90,830 | 146,721 | 223,493 | 288,164 |
| Wire | 142,601 | 174,014 | 161,228 | 136,167 | 149,341 | 171,928 | 229,316 | 244,711 |
| Wire-rods | 6,514 | 5,896 | 10,653 | 7,412 | 20,142 | 22,869 | 22,641 | 65,470 |
| Nails and spikes | 47,756 | 59,491 | 55,826 | 38,906 | 48,055 | 61,201 | 77,833 | 92,497 |
| Pipe and fittings | ..... | ..... | 176,832 | 114,371 | 162,140 | 155,728 | 197,597 | 249,856 |

UNITED STATES IMPORTS OF IRON AND STEEL.
(In tons of 2240 lb.)

| | 1904. | 1905. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|---|---|
| Pig iron | 79,500 | 212,465 | 379,828 | 489,440 | 92,202 | 174,988 | 237,233 | 148,459 | 129,325 |
| Billets, blooms, etc. | 10,807 | 14,637 | 21,337 | 19,334 | 12,112 | 19,913 | 46,578 | 29,205 | 18,702 |
| Scrap iron and steel | 13,461 | 23,731 | 19,091 | 27,687 | 5,090 | 63,704 | 72,764 | 17,272 | 23,612 |
| Bars | 20,905 | 37,298 | 35,793 | 39,746 | 19,672 | 19,206 | 43,692 | 26,729 | 26,112 |
| Rails | 37,776 | 17,278 | 4,943 | 3,752 | 1,719 | 1,513 | ..... | ..... | 3,780 |
| Wire-rods | 16,206 | 17,616 | 17,999 | 17,076 | 11,208 | 10,544 | 20,374 | 15,483 | 15,070 |
| Tinplates | 71,304 | 65,740 | 56,983 | 57,773 | 58,320 | 62,593 | 66,640 | 14,099 | 2,052 |

IRON AND STEEL EXPORTS AND IMPORTS, UNITED STATES.
TOTAL VALUE. (*a*)

| | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|
| Exports | $197,036,781 | $151,113,114 | $157,680,331 | $201,271,903 | $249,656,411 | $289,128,420 |
| Imports | 38,789,992 | 19,957,261 | 30,571,542 | 38,907,119 | 28,995,600 | 29,328,709 |
| Excess, exports: | $158,246,789 | $131,155,853 | $127,108,789 | $162,364,784 | $220,660,811 | $259,799,711 |

(*a*) Including machinery.

The increase in value of exports in 1911 over 1910 was 24 per cent. In 1912 it was 16 per cent. over 1911.

## Total Production of All Kinds of Steel[1]

The production of all kinds of steel ingots and castings in 1912 amounted to 31,251,303 long tons, against 23,676,106 tons in 1911, an increase of almost 32 per cent. The production in 1912 was much the largest in the country's history. The year of next largest production was 1910, when 26,094,919 tons were made. Of the total production in 1912, 30,284,682 tons were ingots and 966,621 tons were castings, against 23,029,479 tons of ingots and 646,627 tons of castings in 1911.

Included in the total for 1912 are about 792,501 tons of ingots and castings which were treated with ferro-vanadium, ferro-titanium, ferro-chrome, nickel, or other alloys, of which about 689,392 tons were ingots

[1] *Statistical Bulletin* of the American Iron and Steel Institute, No. 6, 1913.

and about 103,109 tons were castings, as compared with about 481,459 tons in 1911, of which about 425,169 tons were ingots and about 56,290 tons were castings. Of the total special steels in 1912, about 178,241 tons were Bessemer, 573,880 tons were open-hearth, 30,761 tons were crucible, 9609 tons were electric, and 10 tons were miscellaneous in origin.

STEEL PRODUCTION FOR 13 YEARS.
(In tons of 2240 lb.)

| | Acid. | | | | | | | | Basic. | | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Converter. | | Open-hearth. | | Crucible, etc. | | Total. | | Open-hearth. | | |
| | Tons. | P.c. | Tons. | P.c. | Tons. | P.c. | Tons. | P.c. | Tons. | P.c. | Tons. |
| 1900 | 6,684,770 | 65.6 | 853,044 | 8.4 | 105,424 | 1.0 | 7,643,238 | 75.0 | 2,545,091 | 25.0 | 10,188,329 |
| 1901 | 8,713,302 | 64.7 | 1,037,316 | 7.7 | 103,984 | 0.7 | 9,854,602 | 73.1 | 3,618,993 | 26.9 | 13,473,595 |
| 1902 | 9,138,363 | 61.2 | 1,191,196 | 8.0 | 121,158 | 0.7 | 10,450,717 | 69.9 | 4,496,533 | 30.1 | 14,947,250 |
| 1903 | 8,592,829 | 59.1 | 1,094,998 | 7.5 | 112,238 | 0.8 | 9,800,065 | 67.4 | 4,734,913 | 32.6 | 14,534,978 |
| 1904 | 7,859,140 | 56.7 | 801,799 | 5.8 | 92,581 | 0.7 | 8,755,520 | 63.2 | 5,106,367 | 36.8 | 13,859,887 |
| 1905 | 10,941,375 | 54.6 | 1,155,648 | 5.8 | 111,196 | 0.6 | 12,208,219 | 61.0 | 7,815,728 | 39.0 | 20,023,947 |
| 1906 | 12,275,830 | 52.5 | 1,321,653 | 5.6 | 141,893 | 0.6 | 13,739,376 | 58.7 | 9,658,760 | 41.3 | 23,398,136 |
| 1907 | 11,667,549 | 49.9 | 1,269,773 | 5.5 | 145,309 | 0.6 | 13,082,631 | 56.0 | 10,279,315 | 44.0 | 23,361,946 |
| 1908 | 6,116,755 | 43.7 | 696,304 | 4.9 | 69,763 | 0.5 | 6,882,634 | 49.4 | 7,140,425 | 50.9 | 14,023,247 |
| 1909 | 9,330,783 | 39.0 | 1,076,464 | 4.5 | 130,302 | 0.5 | 10,537,549 | 44.0 | 13,417,472 | 56.0 | 23,955,021 |
| 1910 | 9,412,772 | 36.1 | 1,212,180 | 4.6 | 177,638 | 0.7 | 10,802,599 | 41.4 | 15,292,329 | 58.6 | 26,094,919 |
| 1911 | 7,947,854 | 33.6 | 912,718 | 3.8 | 129,602 | 0.4 | 8,990,174 | 37.8 | 14,685,932 | 62.2 | 23,676,106 |
| 1912 | 10,327,901 | 33.4 | 1,139,221 | 3.6 | 142,679 | 0.4 | 11,609,801 | 37.2 | 19,641,502 | 62.8 | 31,251,303 |

STEEL PRODUCTION OF UNITED STATES AND GERMANY.
(In metric tons.)

| Kind of Steel. | 1910. | | 1911. | | 1912. | |
|---|---|---|---|---|---|---|
| | United States. | Germany. | United States. | Germany. | United States. | Germany. |
| Acid converter | 9,563,376 | 171,108 | 8,075,015 | 187,359 | 10,493,147 | 187,179 |
| Basic converter | ..... | 8,030,571 | ..... | 8,640,164 | ..... | 9,794,300 |
| Total converter | 9,563,376 | 8,047,679 | 8,075,015 | 8,827,523 | 10,493,147 | 9,981,479 |
| Acid open-hearth | 1,231,575 | 252,148 | 927,321 | 383,895 | 1,157,449 | (a) 295,256 |
| Basic open-hearth | 15,537,006 | 5,125,421 | 14,920,907 | 5,668,501 | 19,955,766 | (a) 6,871,896 |
| Total open-hearth | 16,768,581 | 5,377,569 | 15,848,228 | 6,052,396 | 21,113,215 | 7,167,152 |
| Crucible | 124,260 | 83,202 | 99,215 | 78,760 | 123,461 | 79,190 |
| Electric, etc | 56,220 | 36,158 | 32,460 | 60,654 | 21,501 | 74,177 |
| Total | 26,512,437 | 13,698,638 | 24,054,918 | 15,019,333 | 31,751,324 | 17,301,998 |
| Proportions steel to pig iron | 95.6 | 92.6 | 98.6 | 96.8 | 95.1 | 96.8 |

(a) Includes all "Direct Castings."

*Bessemer Steel.*—The production of bessemer steel ingots and castings in 1912 was 10,327,901 tons, against 7,947,854 tons in 1911, an increase of over 29.9 per cent. The production in 1912 was 1,947,929 tons less than in 1906, when the maximum production of 12,275,830 tons was reached. Of the total production in 1912, 10,260,913 tons were made by the standard bessemer process, 33,555 tons by the Tropenas process, and 33,433 tons by other modifications of the standard bessemer process.

MAKE OF ACID AND BASIC STEEL.
(In metric tons.)

| | 1910. | | 1911. | | 1912. | |
|---|---|---|---|---|---|---|
| | Acid (a). | Basic. | Acid (a). | Basic. | Acid (a). | Basic. |
| United States.. | 10,975,431 | 15,537,006 | 9,002,341 | 14,920,907 | 11,650,596 | 19,955,766 |
| Germany..... | 542,616 | 13,155,992 | 571,254 | 14,308,665 | 535,802 | 16,666,196 |
| Total..... | 11,518,047 | 28,692,998 | 9,573,595 | 29,229,572 | 12,186,398 | 36,621,962 |

(a) Including all bessemer steel.

*Open-hearth Steel.*—The total production of open-hearth steel ingots and direct castings in 1912 amounted to 20,780,723 tons, against 15,598,650 tons in 1911, an increase of over 33.2 per cent. In 1908 the production of open-hearth steel for the first time exceeded the production of bessemer steel, the excess amounting to 1,719,974 tons. In 1912 the output of open-hearth steel exceeded the output of bessemer steel by 10,452,822 tons, or over 101.2 per cent. Of the total production of open-hearth steel in 1912, 19,909,875 tons were ingots and 870,848 tons were castings, against 15,027,459 tons of ingots and 571,191 tons of castings in 1911. Of the total output of open-hearth steel in 1912, 19,641,502 tons were made by the basic process and 1,139,221 tons by the acid process, while in 1911 the production by the basic process amounted to 14,685,932 tons and by the acid process to 912,718 tons. Included in the total for 1912 are 413,102 tons of basic and about 160,778 tons of acid open-hearth ingots and castings which were treated with ferro-vanadium, ferro-titanium, ferro-chrome, nickel, etc.

*Crucible Steel.*—The production of crucible steel in 1912 amounted to 121,517 tons, against 97,653 tons in 1911, an increase of over 24.4 per cent. The maximum production was reached in 1907, when 131,234 tons were made. Included in the total for 1912 are about 30,761 tons of crucible steel which were treated with ferro-vanadium, ferro-titanium, ferro-chrome, or other alloys, of which about 27,553 tons were ingots and about 3208 tons were castings. In 1911 the production of treated steel amounted to about 14,732 tons, of which about 13,330 tons were ingots and about 1402 tons were castings.

*Electric and Miscellaneous Steel.*—The production of steel by the electric process in 1912 amounted to 18,309 tons, as compared with 29,105 tons in 1911, a decrease of 10,796 tons. Of the total output in 1912 about 14,147 tons were ingots and about 4162 tons were castings.

*Rails.*—The production of all kinds of rails in the United States in 1912 amounted to 3,327,915 tons, against 2,822,790 tons in 1911, an increase of over 17.8 per cent. Included in the total for 1912 are 174,004 tons of

girder and high T steel rails for electric and street railways, as compared with an output of 205,409 tons of similar rails in 1911.

Of the total production of rails in 1912, 3,165,939 tons were rolled from bessemer, open-hearth, and electric steel blooms or billets; 42,586 tons were rolled from new seconds, defective new rails, and steel crop ends; and 119,390 tons were rerolled from old steel rails or were renewed steel rails. No iron rails are reported for 1912.

RAIL PRODUCTION IN THE UNITED STATES.

(In tons of 2240 lb.)

| Material. | 1910. | 1911. | 1912. | Section. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|
| Bessemer steel | 1,884,442 | 1,053,420 | 1,099,926 | Under 45 lb. | 260,709 | 218,758 | 248,672 |
| Open-hearth steel | 1,751,359 | 1,676,923 | 2,105,144 | 45 to 85 lb. | 1,275,339 | 1,067,696 | 1,118,592 |
| Iron and miscell. | 230 | 92,447 | 122,845 | Over 85 lb. | 2,099,983 | 1,536,336 | 1,960,651 |
| Total | 3,636,031 | 2,822,790 | 3,327,915 | Total | 3,636,031 | 2,822,790 | 3,327,915 |

In the following table the production of titanium, manganese, and other alloy steel rails is given by kind since 1909.

PRODUCTION OF RAILS FROM SPECIAL STEELS.

| Alloy Rails—Gross Tons. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|
| Titanium steel rails | 35,945 | 256,759 | 152,990 | 141,773 |
| Manganese, copper, nickel, etc. | 13,450 | 565 | 999 | 7,494 |
| Total | 49,395 | 257,324 | 153,989 | 149,267 |

## United States Steel Corporation

The annual report of the United States Steel Corporation for 1912 covers the operation of 149 blast-furnaces and steel plants; 114 iron mines in the Lake Superior region and 22 in the Southern group; 104 coal mines and 74 coke plants in the northern, 23 coal mines and 74 coke plants in the southern group. The extent of iron lands owned is not given. Coal lands owned in the North include 134,400 acres coking coal, 93,571 acres steam coal and 24,217 acres surface; in the South 325,020 acres coal and 10,120 acres surface. The coke plants include 25,583 beehive and 1452 by-product ovens. The transportation lines owned cover 976 miles main line and 758 miles branches, equipped with 1203 locomotives and 47,543 cars. Floating equipment includes three ocean steamers, 82 lake and river steamers and 126 barges.

During the latter part of the year substantial appropriations were made for extensions and additions to the various plants and properties. No

considerable amount of expenditures was, however, made on these authorizations during 1912. At the close of the year the amount unexpended on appropriations for construction and extraordinary replacements, including iron-ore mine stripping operations for 1913, equaled approximately $40,000,000. It is estimated, however, that only about $30,000,000 of this will be expended during 1913. These authorizations cover a wide range of sundry additions and improvements.

PRODUCTION OF THE U. S. STEEL CORPORATION.
Including Tennessee C., I., & Ry. Company.

| | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|
| *Iron Ore Mined*— | Tons. | Tons. | Tons. | Tons. | Tons. | Tons. |
| From Marquette Range | 1,170,496 | 830,087 | 899,002 | 830,094 | 560,685 | 551,575 |
| From Menominee Range | 1,625,358 | 1,021,598 | 1,359,415 | 1,386,465 | 1,105,044 | 995,401 |
| From Gogebic Range | 1,425,457 | 1,078,025 | 1,312,701 | 1,801,480 | 1,264,734 | 1,497,950 |
| From Vermilion Range | 1,724,217 | 927,206 | 1,066,474 | 1,338,110 | 1,182,075 | 1,301,663 |
| From Mesabi Range | 16,458,273 | 11,272,397 | 16,968,592 | 17,910,366 | 14,581,530 | 20,001,953 |
| In Southern Region | 1,576,757 | 1,533,402 | 1,824,863 | 1,981,301 | 1,239,563 | 2,079,907 |
| Total | 23,980,558 | 16,662,715 | 23,431,047 | 25,245,816 | 19,933,631 | 26,428,449 |
| *Coke Manufactured* | 13,544,764 | 8,169,931 | 13,590,112 | 13,649,578 | 12,120,212 | 16,719,387 |
| *Coal Mined*, not used in making coke | 3,550,510 | 3,008,810 | 3,089,021 | 4,850,111 | 5,290,671 | 5,905,153 |
| *Limestone Quarried* | 3,201,222 | 2,186,007 | 4,715,708 | 5,005,087 | 4,835,703 | 6,124,541 |
| *Blast Furnace Products*— | | | | | | |
| Pig iron | 11,234,447 | 6,810,831 | 11,436,570 | 11,645,510 | 10,593,726 | 13,990,329 |
| Spiegel | 130,554 | 74,716 | 80,942 | 102,260 | 66,435 | 53,829 |
| Ferro-manganese and Silicon | 57,794 | 48,861 | 100,838 | 83,628 | 84,736 | 142,006 |
| Total | 11,422,795 | 6,934,408 | 11,618,350 | 11,831,398 | 10,744,897 | 14,186,164 |
| *Steel Ingot Production*— | | | | | | |
| Bessemer ingots | 7,556,460 | 4,055,275 | 5,846,300 | 5,796,223 | 5,055,696 | 6,643,147 |
| Open-hearth ingots | 5,786,532 | 3,783,438 | 7,508,889 | 8,383,146 | 7,697,674 | 10,258,076 |
| Total | 13,342,992 | 7,838,713 | 13,355,189 | 14,179,369 | 12,753,370 | 16,901,223 |
| *Rolled and Other Finished Products for Sale*— | | | | | | |
| Steel rails | 1,879,985 | 1,050,389 | 1,719,486 | 2,118,473 | 1,568,028 | 1,857,407 |
| Blooms, Billets, Slabs, Tinplate Bars | 761,195 | 551,106 | 675,614 | 682,364 | 874,474 | 1,103,752 |
| Plates | 894,364 | 312,470 | 729,790 | 929,020 | 630,512 | 1,076,308 |
| Heavy Structural Shapes | 587,954 | 313,733 | 658,516 | 656,797 | 547,186 | 898,537 |
| Merchant Steel, Skelp, Hoops, Bands | 1,338,833 | 577,591 | 1,290,970 | 1,527,506 | 1,221,696 | 1,910,512 |
| Tubing and Pipe | 1,174,629 | 654,428 | 1,013,071 | 868,550 | 863,670 | 1,111,138 |
| Rods | 126,095 | 93,406 | 139,149 | 133,722 | 118,302 | 196,720 |
| Wire and Products of Wire | 1,481,226 | 1,275,785 | 1,607,689 | 1,490,318 | 1,613,754 | 1,629,717 |
| Sheets—Black, Galvanized and Tinplate | 1,070,752 | 770,321 | 1,024,985 | 1,082,787 | 1,079,076 | 1,508,607 |
| Finished Structural Work | 719,887 | 403,832 | 530,766 | 589,228 | 518,399 | 599,301 |
| Angle and Splice Bars and Joints | 195,157 | 84,669 | 190,226 | 235,998 | 160,855 | 192,488 |
| Spikes, Bolts, Nuts and Rivets | 67,991 | 40,252 | 72,076 | 71,326 | 60,386 | 83,426 |
| Axles | 189,006 | 24,057 | 68,366 | 101,066 | 52,046 | 142,367 |
| Sundry Iron and Steel Products | 77,463 | 54,893 | 138,956 | 246,840 | 167,984 | 196,339 |
| Total | 10,564,537 | 6,206,932 | 9,857,660 | 10,733,995 | 9,476,248 | 12,506,619 |
| Spelter | 31,454 | 28,057 | 27,853 | 26,777 | 28,333 | 31,318 |
| Copperas (Sulphates of Iron) | 24,540 | 26,411 | 33,582 | 33,684 | 28,381 | 35,215 |
| Universal Portland Cement (Bbl.) | 2,129,700 | 4,535,300 | 5,786,000 | 7,001,500 | 7,737,500 | 10,114,500 |

In order to meet in a more satisfactory manner the growing demands of the Canadian trade for the products of the subsidiary companies, it has been decided to establish a manufacturing plant in Canada at the site which the Corporation secured some years ago at Ojibway, Ont., opposite the City of Detroit, Mich. The site consists of about 1500 acres with a frontage of about a mile and a half on the Detroit River. The plans for

the scope of the construction of the plant have not yet been fully developed but will probably include blast-furnaces, open-hearth steel works, rail mill, wire mill, structural and bar mills; and perhaps some other mills.

The tonnage output of the manufacturing plants of the subsidiary companies located at Gary, Ind., during 1912 was the largest of any year since their construction, being as follows: Gary steel plant of Indiana Steel Co.: 1,093,578 tons of pig iron, 1,669,389 tons of open-hearth steel ingots, 468,801 tons of open-hearth steel rails and 717,702 tons of various other rolled-steel products. The by-product coke plant produced 2,490,854 tons of coke. The production of the sheet plant was 139,520 tons of black and galvanized sheets, and at the bridge plant were produced 83,018 tons of fabricated steel work.

## The Iron and Steel Markets in 1912

*Alabama* (By L. W. Friedman).—When it is taken into consideration that upward of 200,000 tons of accumulated pig iron were worked off, the market in the southern territory in 1912 was most favorable. Starting at a price near $10 for No. 2 foundry, the year closed with sales being made for delivery during the first half of 1913 at $15 per ton. The unsteady condition throughout the southern iron market for the preceding 2 years was not easy for all concerns. Two companies in Alabama succumbed to the pressure and went into bankruptcy, but late in the year the reorganizations of both concerns were well in hand. Much construction work was done in the southern territory in 1912. One entirely new blast-furnace was built and two others were practically rebuilt.

The plants of the Tennessee Coal, Iron & Railroad Co. enjoyed for the first time a steady operation during the summer and the better part of the year. The year started with the steel industries operating only a portion of the works, and closed with activity on all sides, and with unfilled contracts in hand that will require steady operation for several months to come. The railroads placed many orders for steel rails in the South. The farmers and others bought freely of steel wire during the last few months of the year. Fabricated steel was in steady demand throughout 1912, though the Tennessee company's plant had a limited capacity.

The machine and foundry industry did not fare so profitably as did their kindred interests. Some labor troubles were experienced. Charcoal iron held its own. There was steady operation at car-wheel works in the south. The scrap-iron market had its ups and downs, starting with unsteady trading and closing with considerable activity and satisfactory prices.

*Pittsburg* (By B. E. V. Luty).—The year 1912 in the iron and steel

trade was one of almost spectacular improvement, with respect to prices and the accumulation of business at the mills. In October, 1911, the mills had no accumulation, and were able, as a rule, to make shipment on new specifications in from one day to one week. Rolling schedules were being made up almost from turn to turn, and in the case of merchant mills, rolls were changed almost daily to fill such specifications as became available.

At the close of 1912 the mills had actual specifications on books for an average run at full capacity for about 3 months, with contract business in addition apparently insuring their operation at full capacity into the midsummer period. Rolling schedules were made up long in advance, sometimes permitting several weeks of operation on a single description of material. Buyers requiring prompt delivery were buying in carload and larger lots out of jobbers' stocks, where they could be found, and were also buying from the smaller mills, which do not customarily take contracts, paying in each case very substantial advances over regular mill prices for far forward delivery, even though those had been advanced very substantially during the preceding 13 months.

The advance in pig iron, averaging all important grades in keeping with their commercial importance, was a trifle over $4 a ton from Jan. 1, 1912, to Dec. 31, 1912. About 40 cents of this advance occurred in the first quarter, 40 cents in the second quarter, $2 in the third quarter and $1.25 in the fourth quarter. Southern iron advanced from $9.75, Birmingham, to $14; bessemer iron, Valley, from $14 to $17.25; basic iron, Valley, from $12.25 to $16.50; No. 2 X foundry, Philadelphia, from $14.75 to $18.25; and No 2 foundry, f.o.b. Chicago furnaces, from $14 to $18.

The total advance in finished-steel products, averaging all important descriptions outside of standard-section rails, from the low point in November, 1911, to the close of 1912, was about $6.70 per net ton, but from the subsidiary low point early in 1912, about $6.15 per ton. The advances were fairly uniform in plates, structural shapes, bars, merchant pipe, wire products, sheets and tinplates, but the advance in wire products was the smallest, only $5 a ton from the low point in November, $1.50 for nails, to $1.75 at the close of 1912.

These advances, while fairly large, did not bring prices up to an immoderate level. Both in pig iron and in finished steel, the closing prices of the year were somewhat below the top prices on the 1909 rise, and very much below the prices reached in the great movement of 1905–06–07. The advances had started from a lower level than had been reached for years.

The buying which started in November, 1911, was based chiefly

upon the fact that prices were extremely low. While the mills became better filled with specifications, they did not fall uncomfortably behind in deliveries, nor were they measurably behind in January, 1912. The continuance of fairly heavy buying caused them to begin to fall behind in the spring of the year, and this fact then induced buyers to buy still more freely, and to file heavy specifications against their contracts. Repeating familiar experience in the steel industry, buying begot buying until at the close of 1912 there was a larger volume of genuine business on the books of the steel producers than ever before in their history.

It required no very large tonnage to fill the mills and take up the slack. In the last quarter of 1911, when the lowest prices for years were reached, the mills were operating at about 75 per cent. of capacity, and it required only that actual demand should fill up the gap of 25 per cent. to bring about a condition of buyers contracting and specifying farther and farther ahead. The fact should be emphasized that this was no wonderful increase in the country's demands. The pressure upon mills was brought about rather because the increase in productive capacity in immediately preceding years had been abnormally small. For decades demand and production doubled on an average every 10 years. The rule has not been maintained since 1907. The industry experienced a great chill, when, following the panic in October, 1907, demand so decreased that production dropped off more than 50 per cent. in 3 months, when there was much new construction under way and a capacity greater than ever was promised.

AVERAGE PRICES AT PITTSBURGH, 1912.

| | Pig Iron. | | | Ferro-manganese. | Steel. | | | | | Nails. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bessemer. | Basic. | No. 2 Foundry. | | Bessemer Billets. | Beams. | Plates. | Bars. | Black Sheets No. 28. | Wire per Keg. | Cut per Keg. |
| Jan..... | $14.98 | $13.27 | $13.90 | $42.95 | $19.75 | 1.15c. | 1.15c. | 1.15c. | 1.90c. | $1.57 | $1.50 |
| Feb..... | 14.90 | 13.15 | 13.90 | 42.95 | 19.50 | 1.11 | 1.11 | 1.11 | 1.85 | 1.60 | 1.50 |
| Mar..... | 14.95 | 13.66 | 14.02 | 42.95 | 19.75 | 1.12 | 1.11 | 1.10 | 1.80 | 1.60 | 1.55 |
| Apr..... | 15.15 | 13.88 | 14.15 | 44.49 | 20.25 | 1.20 | 1.20 | 1.15 | 1.85 | 1.60 | 1.55 |
| May..... | 15.13 | 13.90 | 14.15 | 49.20 | 21.00 | 1.25 | 1.25 | 1.20 | 1.90 | 1.60 | 1.55 |
| June..... | 15.15 | 14.11 | 14.15 | 50.45 | 21.25 | 1.26 | 1.26 | 1.21 | 1.90 | 1.60 | 1.55 |
| July..... | 15.15 | 14.38 | 14.29 | 51.22 | 21.50 | 1.30 | 1.30 | 1.25 | 1.96 | 1.62 | 1.55 |
| Aug..... | 15.43 | 14.90 | 14.79 | 53.51 | 22.15 | 1.37 | 1.37 | 1.30 | 2.03 | 1.66 | 1.58 |
| Sept..... | 16.86 | 16.03 | 15.39 | 57.97 | 23.75 | 1.40 | 1.40 | 1.31 | 2.12 | 1.70 | 1.60 |
| Oct..... | 17.90 | 17.08 | 16.99 | 62.23 | 25.75 | 1.47 | 1.47 | 1.39 | 2.20 | 1.70 | 1.63 |
| Nov..... | 18.07 | 17.09 | 17.74 | 63.37 | 26.75 | 1.50 | 1.50 | 1.40 | 2.25 | 1.70 | 1.68 |
| Dec..... | 18.15 | 17.40 | 18.40 | 66.95 | 27.00 | 1.50 | 1.50 | 1.40 | 2.25 | 1.73 | 1.70 |
| Year . | 15.99 | 14.90 | 15.16 | 52.35 | 22.37 | 1.30 | 1.30 | 1.25 | 2.00 | 1.64 | 1.58 |
| 1909 . | 17.46 | 16.44 | 16.40 | 44.42 | 24.58 | 1.41 | 1.41 | 1.31 | 2.26 | 1.82 | 1.77 |
| 1910 . | 17.10 | 15.65 | 15.83 | 42.48 | 25.20 | 1.46 | 1.45 | 1.43 | 2.28 | 1.75 | 1.72 |
| 1911 . | 15.72 | 13.94 | 14.49 | 39.20 | 21.42 | 1.32 | 1.31 | 1.26 | 2.03 | 1.70 | 1.59 |

Prices of pig iron, ferro-manganese and billets are per ton, 2,240 lb.; of steel products, per pound; of nails, per keg of 100 lb.; ferro-manganese and finished steel prices are contract prices for forward delivery.

At the close of 1912 the mills had about 3 months of work at full capacity actually specified on books, and contracts covering from 3 to 5 months additional. Inasmuch as the industry was really undersized for a normal consumptive demand, based on the average rate of increase in the past, it was apparent that a slight decrease in demand could occur without causing a marked reversal, whereas any further increase would cause still greater pressure upon the mills and still higher prices.

*Chicago* (By E. Morrison).—The year 1912 began with a brief period of light business, falling by February into something of depression but quickly recovering and then increasing steadily to activity probably never before paralleled. This change was chiefly the result of the buying of supplies and equipment by the railroads, after a year in which but little had been bought. At the close of 1912 every manufacturing industry of importance in Chicago territory was running at full capacity. Large crops gave assurance that the industries directly dependent on farming, so numerous in this territory, would have continued prosperity.

Opening with a demand for pig iron superior to that for iron and steel products, the year soon developed an abnormal demand for the manufactured products and a lighter demand, relatively, for pig iron. The end of 1911 had been marked by the usual December light buying; January saw Lake Superior charcoal iron selling at $16 @ 16.50; northern No. 2 foundry pig iron at $14 @ 14.50 at the furnace and southern No. 2 foundry iron at $10, Birmingham, or $14.35, Chicago. The cost of northern iron to the consumer was on the average about 50 cents more than the furnace prices, throughout the year. Structural material in January sold as low as 1.30c. and was in light demand; bars were strong with iron bars at 1.15c. minimum and soft-steel bars at 1.25c. minimum, in that month. Sales of pig iron were under 1000 tons each.

Thence on to August increasing activity and larger buying was manifest in the pig-iron market, with a corresponding gain in prices. In September, buying of pig iron became somewhat brisker and by the middle of the month all grades advanced about $1, No. 2 foundry selling at $16.50 for Northern, furnace, and $17.35@ 17.85, Chicago, for Southern. Sales of charcoal iron increased and the price rose to $17.75@18.25. Structural material advanced to 1.58@1.63 cents. Thereafter the market quieted down gradually, mainly because consumers were well supplied. Prices were firm. The end of the year developed the customary quiet in the pig-iron market.

IRON AND STEEL PRICES IN CHICAGO.

| Material. | 1910. | | 1911. | | 1912. | |
|---|---|---|---|---|---|---|
| | Highest. | Lowest. | Highest. | Lowest. | Highest. | Lowest. |
| Lake Superior Charcoal..... | $20.00 | $18.00 | $18.50 | $16.50 | $19.75 | $15.75 |
| Northern No. 2 Foundry..... | 19.50 | 16.00 | 16.50 | 14.00 | 18.25 | 14.00 |
| Southern No. 2 Foundry..... | 18.85 | 15.10 | 15.85 | 14.35 | 18.85 | 14.35 |
| Bar Iron..... | 1.65c. | 1.35c. | 1.35c | 1.15c. | 1.60c. | 1.15c. |
| Structural Material(a)..... | 1.88c. | 1.58c. | 1.63c | 1.30c. | 1.83c. | 1.25c. |

(a) Beams and channels, 3 in. to 15 in., and angles 3 in. to 6 1/4 in. or heavier.

## NOTES ON THE IRON INDUSTRIES OF FOREIGN COUNTRIES

*Algeria.*—The iron ore exported from Algeria was valued at $2,316,000 in 1911, and $2,839,030 in 1912. No iron ore was exported to the United States in 1912.

*China.*—The Hanyang Iron Works, at Hankow, made extensive repairs during 1912. Production is limited, practically the whole output being required to fill contracts with Japanese steel works. There is no probability of pig iron's being shipped from that point to the United States in the near future. American rails are imported, the local works not being able to supply the demand.

No iron ore was declared for shipment to the United States in 1911, and pig-iron shipments fell from 12,950 tons in 1910 to 2425 tons in 1911. The Han-yeh-ping Coal & Iron Co., which controls this business, gives the following figures regarding its operations for the Chinese year, from Jan. 30, 1911, to Feb. 17, 1912: Iron ore mined, 359,467 tons; pig iron produced, 93,337 tons; pig-iron shipments to Chinese ports, 9824 tons; to Japan, 58, 535 tons; to Australia, 5765 tons; to the United States, 4465 tons; to Saigon, Indo-China, 40 tons; rails produced, 24,216 tons; sales of rails and fastenings in China, 23,492 tons.

According to the customs returns, the exports of iron ore and pig iron for the calendar year 1911 were as follows: Iron ore—to foreign ports, 110,500 tons; to Chinese ports, 20 tons; total, 110,520 tons; pig iron—to foreign ports, 51,300 tons; to Chinese ports, 26,128 tons; total, 77,428 tons.

*Cuba* (By D. E. Woodbridge).—Cuban iron ore affairs remained without much change during 1912, although shipments to the United States were 250,000 tons greater than during the previous year, with a total for 1912 of 1,399,965 tons. These shipments were divided as follows among the several companies operating there:

| Spanish-American Iron Co. | Production, Tons. | Shipment, Tons |
|---|---|---|
| Daiquiri division | 537,224 | 463,195 |
| Mayari division (ore) | (a)821,233 | 40,037 |
| Same (nodules) | 503,333 | 406,139 |
| Juragua Iron Co. | 402,560 | 362,600 |
| Ponupo Manganese Co. | 127,328 | 127,994 |
| | | 1,399,965 |

(a) Most of this 821, 233 tons reappears below as nodules.

Prices were low in Cuba, as in the States, and shipments were materially less than productions. But the prospects for the trade during 1913 are far better, and for the same causes that have operated to improve them in the States. The Ponupo Manganese Co., which is the only marketing mining company on the island, reports selling prices on a far better scale than a year ago.

Extensions and betterments were few during the year. The vast deposits at Moa, on the north coast, are yet untouched, and these contain not far from a billion tons. Attempts have been made looking to the opening of the soft ore deposits of Pinar del Rio, but these have not been successful as yet. Reported discoveries of large deposits of high-grade hard limonites there have not been confirmed upon examination. The purchase by the Bethlehem Steel Co. of extensive deposits in Chile, made a few months ago, will have a tendency to retard shipments by the Juragua Iron Co. from the Daiquiri district, amd to postpone still further the development of this company's extensive holdings on the north coast.

Some improvements have been made at the nodulizing works of the Spanish-American company at Felton, north coast. These include the lengthening of the kilns, and changes in the type and character of housing accommodations. Experiments in sintering, as opposed to nodulizing, have not yet been conclusive, though both the Dwight-Lloyd and the Greenawalt processes have been tried to some extent.

*France.*—Iron mining in the Departments of Calvados, Orne, and Manche has become a leading industry. There are twenty-one mining concessions in the basin of Normandy, which cover an area of about 40,000 acres. No statistics for the year 1912 are yet available; but the production of this district in 1911 was 608,494 tons and the exports (principally to Germany) were 348,250 tons, practically the entire exportation being through the port of Caen, Department of Calvados.

The U. S. Consul reports, from Nantes, that an iron mine is to be opened at Chateaubriant, near that city, by the Compagnie Générale des Mines de Fer de Bretagne, of 18 Rue Lafayette, Nantes. The area of the mine is about 3350 acres,

Considerable developments are now contemplated and in progress throughout the French iron and steel industry. Prominent among these is an installation of two blast-furnaces of 200 tons' capacity, each measuring 25 meters in height and 7 meters in diameter, to be loaded automatically on the Stahler system, for the Société Senelle-Maubeuge at Longwy. The plant will include a cylindrical mixer of 500 tons capacity, a large Martin-Talbot open-hearth furnace of 200 tons, three 20-ton converters and two horizontal blowing engines of 4000 h.p. each. The output is estimated at nearly 19,000 tons of ingots a month.

The installation of Jules Collart et Cie., of Steinfort, which has been acquired by the Usines et Aciéries de Steinfort, will be enlarged by the addition of two blast-furnaces and a large steel works.

*India.*—A plant recently installed at Sini, not far from Calcutta, is producing pig iron at $5.40 a ton—paying its blast-furnace men 3 cents per day—and for 48 cents it may be shipped to Calcutta, and there loaded for Pacific ports. The vessels engaged in this trade are principally sailing ships which plan to return from British Columbia with wheat and lumber, and they make a rate of from $5 to $6.50 a ton. For some time they have traded with Japanese ports and British Columbia. One of these ships from Calcutta recently arrived at San Francisco loaded with the first cargo of pig iron from that source to be landed within the Golden Gate. The freight was $5.50, and under the new tariff the iron cost, laid down, $12 a ton, whereas the price now prevailing on the Pacific Coast is about $21.50.

The Tata Iron & Steel Co. (Ltd.) made its first shipment of steel goods in November, 1912. The consignment went to Japan and amounted to 500 tons, worth $16,221—which would be $32 per ton.

*Italy.*—The iron and steel industries of Italy depend almost entirely on the supply of iron ores on the island of Elba, the supply from Sardinia and other points in Italy, principally from Lombardy, being inconsiderable. Little iron ore is now imported into this country, but small lots come from Tunis. As Italy has no coal, the assembling of foreign iron ores and coal at domestic furnaces is commercially impracticable.

The iron mines on the island of Elba are the property of the Italian State. They are worked at present under a lease granted by the Government to Elba Societa Anonima di Miniere e di Alti Forni, and this lease expires in 1923. The royalty is $1.50 per metric ton. The principal mines now worked on this island are at Rio Marina, Rio Elba, Vigneria, Terra Nera, and Calamita. Under the terms of the lease the lessee cannot take out more than 500,000 metric tons per year, but by concessions this has been increased to 600,000 tons. The ore is of the red hematite variety; the best ores yield 58 per cent. and the poorest 44 per

cent. of metallic iron. The remaining deposits on the island are estimated at 18,000,000 tons, and at the present rate of consumption they will be exhausted in 36 years. The richest mines are at Rio Marina and at Rio Elba. The ores are mined by surface workings at a cost of about $1 per ton, exclusive of the royalty. All of the ores are in close proximity to the sea, and their transport to the furnaces at Portoferraio, on the island of Elba, costs 15 cents per ton.

Formerly the iron ores of Elba were exported to foreign countries, mostly to the United Kingdom, and the annual export duties thereon yielded the Italian Government about $10,000,000. The terms of the lease to the Elba Company now in force discourage the export of iron ores to foreign countries and encourage domestic industries. This is accomplished through a provision in the lease under which, on all ores smelted in Italy, the royalty falls to 9 1/2 cents per ton. Two furnace plants, one at Piombino, right opposite the island of Elba, and the other at Bagnoli, near Naples, are entitled annually to specified quantities of the ore mined on Elba, which are to be furnished by the lessee at $1.12 per ton at the mines. Under this arrangement the furnaces at Piombino receive now each year 100,000 tons of ore and the furnaces at Bagnoli 200,000 tons. The requirements of the lessee at Portoferraio are 300,000 tons per year. This arrangement is the basis of the present iron and steel industries of Italy.

Iron and steel and their more or less finished products are now made by the following concerns in Italy:

(1) Società degli Alti Forni, Fonderie ed Acciaierìe di Terni, located at Terni, near Rome, with a capital of $5,000,000. This plant was established with substantial assistance from the government, with the object of rendering Italy independent of foreign countries for its armor plates and various other naval and military requirements. This purpose has been attained. Besides armor plates the works at Terni turn out steel rails and army and navy guns. Pig iron and pig steel are received from Portoferraio, Piombino, and Bagnoli.

(2) The Ilva Co., at Bagnoli, near Naples, with a capital of $3,860,000, was fostered and is still favored by the government, primarily to provide labor for the increasing population in and about the city of Naples and to render Italy still further independent of foreign productions. There are at Bagnoli two blast-furnaces, rolling mills, and coke ovens. The Elba ores are brought by steamers and the coal comes from the United Kingdom and Germany.

(3) Alti Forni, Acciaierìe e Fonderìe di Piombino, capital $4,450,000, located at Piombino, consists of two blast-furnaces, coke ovens, and rolling mills. This concern requires more ore than it is entitled to receive under the lease with the Elba Company and it is now bringing some ores

from the island of Sardinia. These ores come much higher and are not of so good quality as those from Elba.

(4) Società Siderurgica di Savona, at Savona, near Genoa, with a capital of $6,100,000, was organized 12 years ago. It uses iron and steel from Elba and from foreign countries and makes rails and other commercial products.

Elba Società Anonima di Miniere e di Alti Forni was organized in 1899 with the object of acquiring from the government a lease on all the iron-ore lands on the island of Elba, of mining the ores and of making pig iron and steel. This company now has a capital of $6,503,750. Its works are located on the Harbor of Portofarraio, the capital of the island, and consist of three blast-furnaces, two Bessemer converters and four batteries of coke ovens. Two of the latter are French, with 45 ovens each, and two Italian, with 60 ovens each. The average daily consumption of ores is 960 tons and this yields 450 tons of pig iron and 180 tons of steel. The Bessemer converters are of a modern type, while the furnaces are somewhat out of date.

*Japan.*—The Imperial Steel Works of Japan are now on a paying basis, and yielded in 1912 a profit of 2,000,000 yen. The production of the steel works was about 100,000 tons in 1909; 160,000 tons in 1910; 180,000 tons in 1911, and 200,000 tons in 1912.

Imports of pig iron from India (the new Tata iron furnaces) have been very large, and to a certain extent have driven the English article from the market. The Mitsui Bussan Kaisha has been a large buyer both for its own account and also for the government foundry at Wakamatsu. Although the quality of the Indian iron is very much inferior to that of the English, or even of the Chinese formerly imported from the Tayeb Ping concern, importers have the advantage of $2.43 a ton freightage.

*Mexico.*—The only important manufacturer of pig iron in Mexico is the Cia Fundidora de Fierro y Acero, of Monterey, Nuevo Leon. In 1911 the company produced 71,337 tons of pig iron, and in 1910, 45,091 tons. Imports of iron into Mexico are chiefly from Great Britain, the United States, Germany and China.

*Newfoundland.*—The Wabana, Belle Isle, production in 1912 exceeded that of 1911 by 100,000 tons being approximately 1,016,930 tons of which 178,055 went to the U. S.

*Norway.*—In the output of iron ore in 1912, Sydvaranger was an easy first, for despite unforeseen stoppages, including the delay in the delivery of materials owing to the British coal strike, 575,000 tons of ore were mined. Of that quantity about 250,000 tons of slag were produced and briquetted at Kirkenæs to the extent of 160,000 tons. The company's export for 1912 amounted to about 250,000 tons, of which about 100,000

tons went to England and 150,000 tons to Germany. With the completion of the extension in 1913 it is estimated that the yearly capacity of these mines will be from 650,000 to 700,000 tons.

At the Klodeberg mines, near Arendal, about 22,000 and 10,000 tons of first and second quality ores, respectively, were mined. The Fehn mines in Telemarken produced 21,000 tons of ore. As the Salangen iron mines, with briquette works in Tromsö, were closed down at the end of 1911, they would not, strictly speaking, come into the 1912 category, but the output up to December 3 was about 44,500 tons of briquettes. The total production of iron ore from the foregoing in 1912, together with that of some six other operations, was about 400,000 tons, of which about 200,000 tons were briquetted, 100,000 tons in the form of slag, and 100,000 tons sorted ore. The sale value in Norwegian harbors was about 5,500,000 kroner, a considerable increase on the figures of preceding years.

During 1912 the amount of Swedish ore railroaded over the frontier to the Norwegian port of Narvik for shipment was 2,779,130 tons. Of this quantity 2,563,607 tons was Kiruna ore, 147,300 tons Gellevare ore, and 8,800 tons Tuolluvaara ore, all exported by the Kirunabolaget, and 59,423 tons were contributed by the Tuolluvaarabolaget. In all, some 3,200,000 tons of ore were shipped from Norwegian ports in 1912, of which 400,000 tons were Norwegian ore, and the remaining 2,800,000 tons Swedish.

The provisional closing of the Salangen iron mine, following the inactivity in Dunderland, has directed attention to the problem of Norwegian concentrating ores, says the *Min. Journ.*, Nov. 9, 1912. Of the large deposits, Sydvaranger ranks first, with about 37 per cent. of iron in the ore, Dunderland 36 per cent., and Bogen and Salangen 31 per cent.

The trouble at Dunderland arose from the fact that iron glance predominated, about 2 1/2 to 3 times as much glance as magnetite, and to meet the difficulty the Edison magnetic-separation method on the dry principle was adopted, but owing to the dust created it was found (so far as the operatives were concerned) to be unsuitable. This trouble is not present with the Sydvaranger, Salangen and Bogen ores, which are pure magnetite, nor with some smaller deposits.

According to Prof. J. H. L. Vogt, the iron ore available by opencast working, from the chief Norwegian iron deposits, is as follows: Sydvaranger, 100,000,000 tons; Dunderland, 110,000,000 to 120,000,000 tons; Salangen, 30,000,000 tons; Bogen, 15,000,000 tons, and all others, from 75,000,000 to 100,000,000 tons: in round figures 350,000,000 tons of ore, of which 200,000,000 tons are magnetite. In depth to about 100 m. a reserve of 750,000,000 tons can be reckoned with and up to 200 m. about 1,500,000,000 tons of 30 to 36 per cent. iron ore.

Apart from concentrating ores there are in the north of Norway a

number of occurrences of sorting ore, Sydvaranger alone presenting a reserve of at least 4,000,000 tons, possibly 8,000,000 tons, of 52 to 53 per cent. ore; while in the south an effective ore supply of 5,000,000 tons may be reckoned. The successful handling of the titaniferous ore at Rödsand, by the Gröndal process, has drawn attention to similar deposits in the western district. There is an ilmenite deposit at Ekersund, Soggendal, carrying about 39 per cent. $TiO_2$, and 38 per cent. FeO, which places this deposit in a unique position for the production of ferro-titanium, ferro-silicon, titanic acid, etc. Numerous other deposits carry smaller percentages of $TiO_2$. Some of these ores could be hand-sorted to 52 per cent. iron, and most could be magnetically concentrated to 64 to 67 per cent. of $TiO_2$. The potential reserves of the titaniferous ores of Norway are placed by Professor Vogt at about 15,000,000 tons, with a metallic content of about 9,000,000 tons, by which is understood ores with 40 per cent. Fe, and below 8 to 10 per cent. $TiO_2$, calculated as a concentrate of 65 to 68 per cent. Fe.

*Russia.*—The almost continuous growth of the output of Russia's iron and steel industries during the last 5 years is evident in the following table of production in some of the principal lines, the quantities representing short tons:

| Iron and Steel. | 1907. | 1908. | 1909. | 1910. | 1911. |
|---|---|---|---|---|---|
| | Tons. | Tons. | Tons. | Tons. | Tons. |
| Cast-iron, spiegeleisen, ferromanganese, ferrosilicon, and silicospiegel. | 3,095,911 | 3,079,310 | 3,155,324 | 3,340,711 | 3,943,354 |
| Bessemer, Thomas and Martin ingots, puddling and crucible steel, and refined iron. | 3,117,538 | 3,147,195 | 3,441,923 | 4,093,276 | 4,339,016 |
| Castings from reverberatory and Martin crucible furnaces, cast-iron pipes of all kinds and parts. | 256,743 | 264,766 | 263,631 | 292,750 | 349,648 |
| Structural and railway iron and steel, including bars, beams, girders, rails, wire, sheets, plates, flanges, axles, etc. | 2,667,843 | 2,656,123 | 2,931,656 | 3,315,016 | 3,648,647 |
| Soldered iron pipes | 37,524 | 38,317 | 36,985 | 56,440 | 66,172 |
| Railway accessories n. e. s. | 64,624 | 81,939 | 86,362 | 98,830 | 89,259 |

Not included in the above are 1,096,045 tons of steel and iron scrap and 1,791,723 tons of wrought blooms and square, flat pieces of wrought iron produced in 1911.

There were 25 government and 230 private iron and steel works in the Russian Empire in 1911, the government plants being distributed as follows: Ural district, 14; North and Baltic regions, 6; Poland, 5. Of the private concerns 27 were in South Russia, 111 in the Ural district, 42 in the vicinity of Moscow, 5 near the Volga, 19 in the North and Baltic regions, and 26 in Poland. These 255 establishments employed a total of 263,653 workmen—69,394 in South Russia, 112,181 in the Ural district,

27,639 in the vicinity of Moscow, 10,305 in the plants near the Volga, 26,830 in the works in the North and Baltic regions, and 17,304 in Poland.

The unprecedented activity noted in the Russian iron industry during 1912 may be ascribed to (1) the double-tracking of numerous existing railways and the construction of new lines, also the extension of various tramways, and (2) to the increasing use of iron in building operations. The gain in this last item is shown by the following statement of the quantities of "ready iron" finding a sale in Russia during the last 5 years: In 1908, 2,123,280 tons; 1909, 2,365,380 tons; 1910, 2,698,020 tons; 1911, 2,912,400 tons; 1912 (estimated from the returns for the first 8 months), 3,342,200 tons.

To produce these growing amounts of "ready iron" the output of pig iron had also to be increased, the pig-iron production for the last 5 years having been as follows: In 1908, 3,079,800 short tons; 1909, 3,164,400 tons; 1910, 3,340,800 tons; 1911, 3,943,800 tons. In 1912, nearly all of the furnaces were working to their full capacity and some could not fill promptly the orders already accepted. The very natural consequence of this can be seen in the increased imports of pig iron from abroad. In 1908 Russia imported 5400 tons of foreign pig iron; in 1909, 5400 tons; 1910, 7200 tons; 1911, 61,200 tons; 1912, 126,720 tons. It is said that Russian smelters are taking measures to increase their output to meet the demand and retain the home market for themselves.

*South America* (By D. E. Woodbridge).—Interest was excited in the iron ores of Chile by the announcement by C. M. Schwab that his company had purchased the Tofo deposits, in Coquimbo, Chile, and proposed to begin development at once with the view of supplying its furnaces therefrom. Figures have been computed by Mr. Schwab which show the cost of delivering this ore to furnaces to be 7 cents per unit, or about $4.70 a ton for the grade likely to be shipped at once, this including all charges. The ore lies close to the sea, and can be handled to steamers from the mines on gravity trams. A difficulty in the way of cheap handling and rapid loading is to be found in the fact that the bay of Cruz Grande, where ships must lie, is open to the west, so that loading cannot proceed during bad weather. The Tofo deposits are practically unmeasured, but are known to be very large.

Negotiations have been under way for a year between English capitalists and the Brazilian Government looking toward the opening of the vast and high-grade deposits of Minas Geraes, and these have not yet been concluded. But they have proceeded so far that the Englishmen have taken over the narrow-gage railway running from Rio to the mining region, and will rebuild it with added capacity as soon as they are assured of their position with reference to the government. The

engineering public is aware that these are perhaps the largest iron ore deposits on the globe, and that they are of high grade, that they lie 350 miles from the sea and that they can be quarried. The cost of rail transportation is the main item of cost in connection with these ores. It is probable that they will become a very material source of supply for American and European furnaces at no distant day.

The Imataca mines, on the Orinoco River, in Venezuela, have again come into notice by reason of the purchase of a part of the properties by the Canadian Venezuelan Iron Ore Co., with headquarters in Montreal, and the arrival of a few small cargoes. The ore is of exceedingly high grade and is bessemer, but there has always been considerable disagreement among engineers as to probable quantities. It is now stated that the work of the Canadian company has proved more than 10,000,000 tons in sight. This is many fold more than some engineers have given the deposit credit for, and many times less than others have been able to find probable. The main disadvantage under which these mines labor, providing the quantity is at hand, is the shallow depth of water in the Orinoco river, forbidding the shipment of large cargoes, and the unsettled condition of Venezuelan politics. Doubtless both these objections can be overcome.

*South Africa.*—A new industry was recently started on the Rand, between Boksburg and Benoni, to deal with the local supply of scrap iron and steel, by the Union Steel and Iron Works. It is the first plant in South Africa for the systematic conversion of scrap metal into bars, angles, etc., for which there is a large demand, particularly from mines and railways.

Another company, also organized for treating scrap iron and steel, is erecting a plant at Vereeniging, on the banks of the Vaal River, where the Victoria Falls Power Co. has a large station. This is known as the Union Steel Corporation of South Africa (Ltd.), and has large capital behind it. The latter company has entered into a 16-year contract with the Government of the Union of South Africa for the purchase of all of the scrap iron and steel possessed by the government railways, at $4.86 per ton, and active operations for the conversion of this material into new products for local consumption will soon be started.

*Spain.*—An unusual amount of activity in mining circles has arisen since the announcement in November, 1912, that the Spanish government had sanctioned the project of building a railway from Torre del Mar, near Malaga, to Zurgena, in the Province of Almeria, through sections undoubtedly rich in iron ore and other minerals. Mining men and engineers have arrived from the Bilbao districts, from Seville, and from England, and many of these are actively engaged in preliminary work.

It is certain that more and more iron ore will be shipped from this port each succeeding year and it is believed that the development will be rapid.

At present one all-British and one German-British company export ore regularly from Almeria and several individuals dispatch a shipload occasionally. These latter have small holdings or buy from various superficially worked mines scattered among the hills. During 1912, 336,960 metric tons of iron ore were shipped from this port, and while that was a decrease of 66,684 metric tons as compared with 1911, the high freight rates and labor troubles in England, to which country most of the ore is exported, may be assigned as the direct causes.

*Sweden.*—An agreement between the Swedish government and the companies controlling the fields of Kirunavara and Gellivara limits the exportation to an annual amount of 4,500,000 tons. The increase of this limitation is being considered, on account of the German demand and also on account of the tremendous ore reserves, which are estimated at 1,000,000,000 tons.

For some time past, a German syndicate has been examining and making trial bores on the Intraangets iron deposits, Garpenberg, which belong to the Stora Langviks Gruf. A. B. The work has been carried on in the name of a subsidiary company, the Intraangets Grufvars Direction and the German syndicate has now made final arrangements with the owners for the purchase of the mines.

A valuable account of the iron-ore deposits in central and southern Sweden is found in a volume recently published in Stockholm, under the direction of F. R. Tegengren, under authority of the Swedish government. The ore deposits examined have been divided into three groups:

(1) Ores containing less than 0.01 per cent. of phosphorus, suitable for the production of high-grade iron by the acid and Martin methods.

(2) Ores with from 0.01 to 0.06 per cent. of phosphorus, suitable only for working by the Lancashire method.

(3) Ores containing more than 0.06 per cent. of phosphorus and suitable only for working by the basic method.

Each of these three groups has been divided further into ore suitable for use in its natural state and ore fit for use only after concentration, in addition to which the estimated quantity of "slig" (wet concentrates from which briquets of concentrated ore are made) from the raw ore last mentioned is also stated.

The supply of ore under group 1, where mines are being, or have recently been, worked in central and southern Sweden, is estimated to be 38,273,000 tons; under group 2 the estimate is 21,796,000 tons; and of group 3 it is placed at 60,484,000 tons, making in all a total of 120,553,000 tons. To this may be added certain ore deposits worked long ago,

which are not so well known at present and which are estimated to contain 37,000,000 tons.

Three blast furnaces at Hagfors are built, two being in operation. Three types of iron are produced. One for gray Martin's steel, another for white puddle steel, and another for Bessemer. In 1912, 6,707 tons of pig iron were used for the Martin process, and 1,088 tons for the Bessemer process, for an average of 270 tons per week.

STEEL PRODUCTION OF AUSTRIA-HUNGARY.
(In metric tons.)

| Steel. | 1911. | | | 1912. | | |
|---|---|---|---|---|---|---|
| | Austria. | Hungary. | Bosnia. | Austria. | Hungary. | Bosnia. |
| Acid converter | 360 | 34,058 | ..... | ..... | ..... | ..... |
| Basic converter | 293,750 | ..... | ..... | ..... | ..... | ..... |
| Open-hearth | 1,268,907 | 675,477 | 35,508 | ..... | ..... | ..... |
| Puddled | ..... | ..... | ..... | ..... | ..... | ..... |
| Crucible | 30,655 | 1,326 | ..... | ..... | ..... | ..... |
| Electric | 21,706 | 1,261 | ..... | ..... | ..... | ..... |
| Total steel | 1,615,378 | 712,122 | 35,508 | 1,953,214 | 793,308 | 38,583 |
| Puddled (wrought) iron | 91,266 | 11,463 | ..... | ..... | ..... | ..... |
| Total | 1,706,644 | 723,585 | 35,508 | ..... | ..... | ..... |

PIG IRON PRODUCTION IN BELGIUM.
(In metric tons.)

| | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|
| Foundry iron | 101,430 | 100,020 | 76,190 | 89,960 | (a) 83,710 | (a) 60,630 | (a) 96,620 |
| Forge iron | 226,900 | 226,430 | 127,630 | 156,590 | 115,760 | 102,690 | 66,940 |
| Steel pig | 1,103,130 | 1,101,490 | 1,002,620 | 1,386,800 | 1,652,620 | 1,882,960 | 2,137,730 |
| Total | 1,431,460 | 1,427,940 | 1,206,440 | 1,632,350 | 1,852,090 | 2,046,280 | 2,301,290 |

(a) Includes special cast irons.

FOREIGN IRON AND STEEL TRADE OF BELGIUM.
(In metric tons.)

| | Imports. | | | | Exports. | | | |
|---|---|---|---|---|---|---|---|---|
| | 1908. | 1909. | 1910. | 1911. | 1908. | 1909. | 1910. | 1911. |
| Pig iron | 481,124 | 477,311 | 687,001 | 693,235 | 119,095 | 19,362 | 14,695 | 11,610 |
| Wrought iron and steel | 270,273 | 360,255 | 360,422 | 358,411 | 941,374 | 1,177,693 | 1,406,190 | 1,498,104 |
| Total | 751,397 | 837,566 | 1,047,423 | 1,051,646 | 1,060,469 | 1,197,055 | 1,420,885 | 1,509,714 |

PIG IRON PRODUCTION IN CANADA. (a)
(In tons of 2240 lb.)

| | 1905. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|---|
| y and forge..... | 146,698 | 130,120 | 84,979 | 114,951 | 149,580 | 153,626 | 224,791 | 194,337 |
| ıer..... | 149,203 | 165,609 | 154,910 | 112,811 | 169,545 | 221,494 | 186,274 | 228,742 |
| ..... | 172,102 | 246,228 | 341,257 | 335,410 | 357,965 | 365,090 | 413,303 | 489,799 |
| l..... | 468,003 | 541,957 | 581,146 | 563,172 | 677,090 | 740,210 | 824,368 | 912,878 |

As reported by American Iron and Steel Institute.

STEEL PRODUCTION IN CANADA. (a)
(In tons of 2240 lbs.)

| | 1911. | | | | 1912. | | | |
|---|---|---|---|---|---|---|---|---|
| | Con-verter. | Open-hearth. | Special. | Total. | Con-verter. | Open-hearth. | Special. | Total. |
| ..... | 189,797 | 581,222 | ..... | 771,019 | 207,569 | 617,061 | 400 | 825,030 |
| s..... | ..... | 19,852 | ..... | 19,852 | ..... | 28,001 | ..... | 28,001 |
| l..... | 189,797 | 601,074 | ..... | 790,871 | 207,569 | 645,062 | ..... | 853,031 |

As reported by American Iron and Steel Institute.

PIG IRON PRODUCTION IN FRANCE.
(In metric tons.)

| | 1905. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911 (a). | 1912(a). |
|---|---|---|---|---|---|---|---|---|
| y..... | 635,672 | 591,275 | 651,700 | 695,527 | 749,247 | 760,622 | 836,454 | 825,682 |
| ..... | 705,691 | 741,571 | 673,885 | 543,067 | 538,053 | 556,767 | 586,496 | 568,164 |
| er..... | 160,411 | 149,971 | 122,046 | 118,121 | 118,002 | 104,966 | 104,265 | 117,221 |
| ..... | 1,530,671 | 1,784,726 | 1,988,343 | 1,949,107 | 2,172,718 | 2,549,908 | 2,777,261 | 3,304,518 |
| irons.. | 44,267 | 51,489 | 152,975 | 85,328 | 54,085 | 60,196 | 122,113 | 56,407 |
| l..... | 3,076,712 | 3,319,032 | 3,588,949 | 3,391,150 | 3,632,105 | 4,032,459 | 4,426,469 | 4,871,992 |

As reported by the Comité des Forges.

IRON AND STEEL PRODUCTION IN FRANCE.
(In metric tons.)

| | 1905. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|---|
| ıt iron. | 669,841 | 747,900 | 687,249 | 563,745 | 519,200 | 501,100 | 462,681 | (c)450,000 |
| gots... | 2,210,284 | 2,436,322 | 2,766,773 | 2,727,617 | 3,034,571 | 3,506,497 | 3,680,613 | 4,078,352 |
| d steel. | 1,442,071 | 1,454,456 | 2,261,217 | 1,894,022 | 2,043,022 | 2,684,000 | 2,638,484 | 3,028,799 |

Estimated.

PRODUCTION OF PIG IRON IN GERMANY.
(In metric tons.)

| | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912 (a). |
|---|---|---|---|---|---|---|---|
| y iron..... | 2,108,684 | 2,259,416 | 2,254,644 | 2,491,919 | 2,968,810 | 2,881,059 | 3,338,839 |
| ron..... | 854,536 | 786,113 | 635,228 | 652,306 | 644,992 | 689,881 | 525,423 |
| g..... | 943,573 | 1,034,650 | 934,940 | 1,099,779 | 1,327,196 | 1,547,480 | 2,201,489 |
| er pig..... | 482,740 | 471,355 | 361,472 | 412,118 | 471,366 | 377,051 | 388,855 |
| pig..... | 8,088,534 | 8,494,226 | 7,627,227 | 8,261,538 | 9,338,961 | 9,785,056 | 11,397,965 |
| ..... | 12,478,067 | 13,045,760 | 11,813,511 | 12,917,653 | 14,793,325 | 15,280,527 | 17,852,571 |

As reported by the German Iron and Steel Union.

PRODUCTION OF STEEL IN GERMANY.
(In metric tons.)

| | 1909. | | 1910. | | 1911. | | 1912 (a). | |
|---|---|---|---|---|---|---|---|---|
| | Acid. | Basic. | Acid. | Basic. | Acid. | Basic. | Acid. | Basic. |
| Converter ingots... | 151,148 | 7,517,451 | 171,108 | 8,030,571 | 187,359 | 8,640,164 | 187,179 | 9,794,300 |
| Open-hearth ingots | 311,812 | 3,967,581 | 252,148 | 5,125,421 | 383,895 | 5,668,501 | 295,256 | 6,871,896 |
| Special steels..... | 101,842 | ..... | 119,390 | ..... | 139,414 | ..... | 153,367 | ..... |
| Total (b)..... | 564,802 | 11,485,032 | 542,646 | 13,155,992 | 710,668 | 14,308,665 | 635,802 | 16,666,196 |

(a) As reported by the German Iron and Steel Union. (b) Includes direct castings.

GROWTH OF CONSUMPTION OF IRON IN GERMANY.
(In metric tons.)

| | 1907. | 1908. | 1909. | 1910. | 1911. | 1912 (b). |
|---|---|---|---|---|---|---|
| Pig iron production..... | 13,045,760 | 11,813,511 | 12,917,653 | 14,793,325 | 15,652,004 | 17,868,909 |
| Imported as pig..... | 607,729 | 399,661 | 318,938 | 383,039 | 412,501 | 481,089 |
| Imported as steel, etc. (a)..... | 459,060 | 344,583 | 479,513 | 376,884 | 434,672 | 406,839 |
| Total supply..... | 14,112,549 | 12,557,755 | 13,716,114 | 15,553,248 | 16,499,177 | 18,756,837 |
| Exported as pig..... | 385,766 | 421,611 | 644,935 | 933,456 | 1,003,607 | 1,217,968 |
| Exported as steel, etc. (a)..... | 4,706,587 | 4,930,399 | 5,032,653 | 5,828,243 | 6,508,440 | 7,188,405 |
| Total exports..... | 5,092,353 | 5,352,010 | 5,677,588 | 6,761,699 | 7,512,047 | 8,406,373 |
| Consumption..... | 9,020,196 | 7,205,745 | 8,038,526 | 8,791,549 | 8,987,306 | 10,350,464 |
| Consumption per head, kg..... | 145.1 | 114.4 | 125.8 | 136.0 | 136.9 | 159.0 |

(a) Reduced to terms of pig iron at the rate of 1 ton steel = 1.33 tons pig iron.
(b) Reported by German Iron and Steel Union. The figure for production is the revised total.

PRODUCTION OF IRON AND STEEL IN RUSSIA.
(In metric tons.)

| | 1903. | 1904. | 1905. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. |
|---|---|---|---|---|---|---|---|---|---|
| Iron ore..... | 4,218,600 | 5,272,300 | 4,050,000 | 4,580,000 | 4,400,000 | 4,450,000 | 4,750,000 | 4,595,000 | 5,101,000 |
| Pig iron..... | 2,486,610 | 2,978,325 | 2,125,000 | 2,350,000 | 2,768,220 | 2,748,000 | 2,871,332 | 2,740,000 | 2,865,000 |
| Steel ingots..... | 2,410,938 | 2,811,948 | 1,650,000 | 1,763,000 | 2,076,000 | 2,341,000 | 2,477,000 | 2,350,000 | 2,519,000 |

PRODUCTION OF IRON AND STEEL IN SPAIN.
(In metric tons.)

| | 1903. | 1904. | 1905. | 1906.(a) | 1907.(a) | 1908.(a) | 1909.(a) | 1910. | 1911. |
|---|---|---|---|---|---|---|---|---|---|
| Pig iron..... | 380,284 | 386,000 | 383,100 | 387,500 | 385,000 | 375,000 | 389,000 | 367,000 | 353,500 |
| Wrought iron..... | 53,288 | 53,177 | 52,250 | 57,100 | 53,200 | 51,000 | 49,500 | 43,250 | 40,170 |
| Bessemer steel..... | 105,263 | 93,100 | 113,664 | 116,200 | 115,500 | 111,500 | 113,250 | 101,250 | 96,720 |
| Open-hearth steel..... | 94,379 | 100,659 | 124,200 | 135,400 | 131,600 | 128,000 | 113,750 | 118,750 | 131,510 |
| Total steel..... | 199,642 | 193,759 | 237,864 | 251,600 | 247,100 | 239,500 | 227,000 | 219,500 | 225,230 |

(a) Estimated.

SWEDISH PRODUCTION AND EXPORTS.
(In metric tons.)

| | 1910. | | | 1911. | | | 1912. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Pig. Iron. | Wrought Iron. | Steel. | Pig Iron. | Wrought Iron. | Steel. | Pig Iron. | Wrought Iron. | Steel. |
| uction | 604,300 | 150,500 | (*b*)468,600 | 633,800 | 146,700 | (*c*)456,500 | 701,900 | 148,100 | (*a*)508,300 |
| rts.... | 143,500 | 106,700 | 171,100 | 158,400 | 90,600 | 169,300 | 204,800 | 85,300 | 190,300 |

Includes 107,200 tons bessemer and 401,100 open-hearth. (*b*) Includes 97,900 tons bessemer and 00 tons open-hearth. (*c*) Includes 93,800 tons bessemer and 362,700 tons open-hearth steel.

UNITED KINGDOM, PIG IRON AND WROUGHT IRON.
(In tons of 2240 lb.)

| | 1909. | 1910. | 1911. |
|---|---|---|---|
| iron..... | 9,664,394 | 10,216,745 | 9,718,638 |
| ught or puddled iron.... | 1,129,412 | 1,118,893 | 1,191,499 |

PRODUCTION OF STEEL IN THE UNITED KINGDOM.
(In tons of 2240 lb.)

| | 1903. | 1904. | 1905. | 1906. | 1907 | 1908. | 1909. |
|---|---|---|---|---|---|---|---|
| -hearth..... | 3,124,083 | 3,245,346 | 3,879,748 | 4,554,936 | 4,663,489 | 3,817,103 | 4,148,408 |
| mer..... | 910,018 | 1,781,533 | 2,009,712 | 1,907,338 | 1,859,259 | 1,478,539 | 1,733,220 |
| tal..... | 4,034,101 | 5,023,879 | 5,889,460 | 6,462,274 | 6,522,748 | 5,295,642 | 5,881,628 |

ACID AND BASIC STEEL IN THE UNITED KINGDOM.
(In tons of 2240 lb.)

| | 1910. | | | 1911. | | | 1912 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Acid. | Basic. | Total. | Acid. | Basic. | Total. | Acid. | Basic. | Total. |
| -hearth..... | 3,016,830 | 1,578,536 | 4,595,366 | 3,131,218 | 1,869,254 | 5,000,472 | ..... | ..... | ..... |
| rter..... | 1,138,103 | 641,012 | 1,779,115 | 887,767 | 573,373 | 1,461,140 | ..... | ..... | ..... |
| l..... | 4,154,933 | 2,219,548 | 6,374,481 | 4,018,985 | 2,442,627 | 6,461,612 | ..... | ..... | ..... |

IRON AND STEEL TRADE OF THE UNITED KINGDOM.
(Values.)

| | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912.(*a*) |
|---|---|---|---|---|---|---|---|
| ts..... | £75,256,655 | £88,448,689 | £78,914,315 | £77,589,552 | £91,544,552 | £90,612,551 | £96,944,791 |
| ts..... | 13,486,724 | 12,527,157 | 12,236,417 | 16,128,959 | 19,917,125 | 23,622,122 | 26,815,835 |

e.—Exports and imports include values of machinery, hardware, and new ships. (*a*) From offi- rade and Navigation Accounts.

## IRON AND STEEL EXPORTS, UNITED KINGDOM.
(In tons of 2240 lb.)

| | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912(a). |
|---|---|---|---|---|---|---|---|
| Pig iron | 1,662,820 | 1,947,925 | 1,295,767 | 1,136,369 | 1,205,863 | 1,204,319 | 1,263,835 |
| Wrought iron | 200,182 | 211,771 | 172,072 | 170,189 | 141,747 | 138,089 | 142,461 |
| Sheets | 442,414 | 469,329 | 390,281 | 494,826 | 597,117 | 617,557 | 658,680 |
| Plates | 275,045 | 300,590 | 207,278 | 167,797 | 250,867 | 267,691 | 282,898 |
| Rails | 460,328 | 433,638 | 435,739 | 571,524 | 485,693 | 370,543 | 412,127 |
| Steel shapes, etc. | 226,230 | 338,716 | 275,022 | 305,530 | 369,020 | 347,828 | 361,992 |
| Tin plates | 374,802 | 405,329 | 403,007 | 439,804 | 483,020 | 484,355 | 480,910 |
| All other kinds | 1,040,379 | 1,059,068 | 921,810 | 932,024 | 1,208,578 | 1,088,727 | 1,211,102 |

(a) From official Trade and Navigation Accounts.

## PIG IRON PRODUCTION OF THE WORLD.
(In metric tons.)

| Year. | Austria-Hungary. | Belgium. | Canada. | France. | Germany. | Italy. | Russia. |
|---|---|---|---|---|---|---|---|
| 1903 | 1,355,000 | 1,299,211 | 269,665 | 2,827,668 | 10,085,634 | 28,250 | 2,486,610 |
| 1904 | 1,369,500 | 1,307,399 | 274,777 | 2,999,787 | 10,103,941 | 27,600 | 2,978,325 |
| 1905 | 1,372,300 | 1,310,290 | 475,491 | 3,077,000 | 10,987,623 | 31,300 | 2,125,000 |
| 1906 | 1,403,500 | 1,431,160 | 550,618 | 3,319,032 | 12,478,067 | 30,450 | 2,350,000 |
| 1907 | 1,405,000 | 1,427,940 | 590,444 | 3,588,949 | 13,045,760 | 32,000 | 2,768,220 |
| 1908 | 1,650,000 | 1,206,440 | 572,123 | 3,391,150 | 11,813,511 | 112,924 | 2,748,000 |
| 1909 | 1,958,786 | 1,632,350 | 687,923 | 3,632,105 | 12,917,653 | 207,800 | 2,871,332 |
| 1910 | 2,010,000 | 1,852,090 | 752,090 | 4,032,459 | 14,793,325 | 215,000 | 2,740,000 |
| 1911 | 2,095,000 | 2,046,280 | 837,558 | 4,426,469 | 15,280,527 | 235,000 | 2,865,000 |
| 1912 | ..... | 2,301,290 | 927,484 | 4,871,992 | 17,852,571 | ..... | ..... |

| Year. | Spain. | Sweden. | United Kingdom. | United States. | All Other Countries. | Total. |
|---|---|---|---|---|---|---|
| 1903 | 380,284 | 506,825 | 8,952,183 | 18,297,400 | 625,000 | 47,113,730 |
| 1904 | 386,000 | 528,525 | 8,699,661 | 16,760,986 | 633,000 | 46,069,501 |
| 1905 | 383,100 | 531,200 | 9,746,221 | 23,340,258 | 655,000 | 54,054,783 |
| 1906 | 387,500 | 552,250 | 10,311,778 | 25,706,882 | 650,000 | 59,074,861 |
| 1907 | 385,000 | 603,100 | 10,082,638 | 26,193,863 | 556,900 | 60,680,014 |
| 1908 | 403,500 | 563,300 | 9,438,477 | 16,190,994 | 550,000 | 48,640,479 |
| 1909 | 389,000 | 443,000 | 9,818,916 | 26,108,199 | 550,000 | 61,217,064 |
| 1910 | 367,000 | 604,300 | 10,380,723 | 27,636,687 | 525,000 | 65,908,674 |
| 1911 | 353,500 | 633,800 | 9,874,620 | 24,027,940 | 535,000 | 63,210,694 |
| 1912 | ..... | 701,900 | ..... | 30,202,568 | ..... | ..... |

## STEEL PRODUCTION OF THE WORLD.
(In metric tons.)

| Year. | Austria-Hungary. | Belgium. | Canada. | France. | Germany. | Italy. | Russia. |
|---|---|---|---|---|---|---|---|
| 1902 | 1,143,900 | 776,875 | 184,950 | 1,635,300 | 7,780,682 | 119,500 | 2,183,400 |
| 1903 | 1,146,000 | 981,740 | 181,514 | 1,854,620 | 8,801,515 | 116,000 | 2,410,938 |
| 1904 | 1,195,000 | 1,069,880 | 151,165 | 2,080,554 | 8,930,291 | 113,800 | 2,811,948 |
| 1905 | 1,188,000 | 1,023,500 | 403,449 | 2,210,284 | 10,066,553 | 117,300 | 1,650,000 |
| 1906 | 1,195,000 | 1,185,660 | 515,200 | 2,371,377 | 11,135,085 | 109,000 | 1,763,000 |
| 1907 | 1,195,500 | 1,183,500 | 516,300 | 2,677,805 | 12,063,632 | 115,000 | 2,076,000 |
| 1908 | 2,025,182 | 1,065,500 | 598,183 | 2,727,717 | 10,480,349 | 537,000 | 2,341,000 |
| 1909 | 1,969,538 | 1,370,000 | 766,795 | 3,034,571 | 12,049,834 | 661,600 | 2,471,000 |
| 1910 | 2,188,371 | 1,449,500 | 835,478 | 3,506,497 | 13,698,638 | 635,000 | 2,350,000 |
| 1911 | 2,363,008 | 1,537,000 | 880,278 | 3,680,613 | 15,019,333 | 646,500 | 2,519,000 |
| 1912 | 2,785,105 | 1,954,490 | ..... | 4,078,352 | 17,301,998 | ..... | ..... |

| Year. | Spain. | Sweden. | United Kingdom. | United States. | All Other Countries. | Total. |
|---|---|---|---|---|---|---|
| 1902..... | 163,564 | 283,500 | 5,102,420 | 15,186,406 | 412,000 | 34,972,497 |
| 1903..... | 199,642 | 317,107 | 5,114,647 | 14,756,691 | 418,000 | 36,298,414 |
| 1904..... | 193,759 | 333,522 | 5,107,309 | 13,746,051 | 415,000 | 36,148,079 |
| 1905..... | 237,864 | 340,000 | 5,983,691 | 20,354,291 | 426,000 | 43,900,648 |
| 1906..... | 251,600 | 351,900 | 6,565,670 | 23,772,506 | 420,000 | 49,635,998 |
| 1907..... | 247,100 | 443,000 | 6,627,112 | 23,733,391 | 405,000 | 51,273,340 |
| 1908..... | 239,500 | 427,100 | 5,380,372 | 14,247,619 | 300,000 | 44,359,522 |
| 1909..... | 227,000 | 310,600 | 5,975,734 | 24,338,302 | 325,000 | 53,499,974 |
| 1910..... | 220,000 | 468,600 | 6,476,791 | 26,512,437 | 315,000 | 58,656,312 |
| 1911..... | 228,230 | 456,500 | 6,565,321 | 24,054,918 | 325,000 | 58,275,701 |
| 1912..... | ..... | 508,300 | ..... | 31,751,324 | ..... | ..... |

## The Metallurgy of Iron and Steel in 1912[1]

By Bradley Stoughton

Probably more attention was given in America in 1912 to improvement in the quality of iron and steel than during any other year. This is particularly true of steel for rails, and of means for eliminating defects so liable to be found in ingots, namely: pipes, blow-holes, segregation, and solid inclosures. Copper in small proportions is a new addition to steel, and the natural alloys of iron with nickel and chromium, known as Mayari iron and Mayari steel, were publicly described in 1912 for the first time. New impetus was given to the scientific study of cast iron, and to the determination of the "Widmanstätten structure" in steel. Several useful discoveries were made in the case hardening of steel and the ferromagnetism of steel and other alloys. In the manufacturing side of the industry, there were decided developments in the preparation of ores for smelting; in thin-lined furnaces, and in drying of blast. The following novelties in practice were adopted: New chilled cast-iron process, new open-hearth fuel, new open-hearth raw material, new processes for casting small ingots, and new process for making charcoal wrought iron. Electric furnaces, the duplex process, and mechanical puddling were installed in large plants not previously so equipped.

*Improvement of Railroad Rails.*—Perhaps the most striking immediate result of the study given to this subject by both consumers and manufacturers is the recently adopted extension of the field of inspection of manufacture, so that a small army of inspectors in the works records the history of manufacture of every rail produced. Hunt[5] and others have gone on record that the great problem next to be solved is to secure a sound ingot—that is, substantially free from segregation, slag inclosures, blow-holes, and a deep pipe. Then the laminated heads, streaked heads

[1] *Eng. and Min. Journ.*, Jan. 11, 1913.

and flanges, and sharp fractures due to a veil of occluded alumina or other oxide, will become things of the past. The importance of distribution of metal between head, web, and flange has been shown by the published records[16] of the relation between the temperature and proportion of rail failures on all the Harriman lines. Records of the previous 80-lb. and 90-lb. *A. S. C. E.* sections showed that the average number of failures in the cold months of 1909, 1910 and 1911 was double or treble the number occurring in the warm months; with the 90-lb. section of the American Railway Association, the average number of failures in the cold months was substantially no greater than in the warm months, and always less than with the older sections.

*Producing Sound Ingots.*—At the autumn meeting of the Iron and Steel Institute[6] Sir Robert Hadfield, Dr. J. E. Stead and Dr. Hans Goldschmidt each described a new method of avoiding pipes or blow-holes, or both. The Hadfield process consists in heating the top of the ingot by means of a charcoal fire and the result is seen to be a marked decrease in segregation, depth of pipe and amount of necessary discard. Stead described the process of Benjamin Talbot,[4] which consists in rolling the ingot before it has solidified inside, and so obtaining the advantages of liquid compression at lower cost. In the Talbot process we get the effect ordinarily found in rolling "green" ingots, namely, an impoverishment of non-ferrous elements in the center of the ingot, instead of segregation there. The new Goldschmidt process involves plunging a can of thermit to the bottom of the liquid ingot so as to free it from gases, oxide inclosures, etc., by the violent stirring produced by the thermit reaction.

*Blow-holes and Slag Inclosures.*—The subject of slag inclosures was thoroughly treated by Packer and Mars.[1] A new process was adopted in the Obouchoff Steel Works for the prevention of surface blow-holes, and was described by Traubine.[6,13] The ingots are teemed through a sheet-iron truncated cone which is suspended always just above the surface of the liquid metal. The splashes of metal which would otherwise strike on the walls of the ingot mold and adhere there, are caught by the walls of this cone, which is entirely encrusted with them when pouring it over. Since this practice has been in vogue, the ingots have been free from surface blow-holes. Stead[6] published part II of his study of the welding-up of blow-holes, which publication is said by Howe to be the most important contribution on the subject ever published. Stead announces the following conclusion: "It seems reasonable to believe that under the ordinary treatment to which honeycombed ingots of steel are heated and rolled, internal small cavities or blow-holes do become perfectly welded up, provided there is an absence of sulphide segrega-

tions. * * * * * It also seems justifiable to conclude that surface blow-holes which become oxidized on their walls during the heating and rolling of the ingot, do become more or less completely welded. The conditions favorable to this welding must be a sufficiently high temperature and maintenance of the steel at that temperature for a long enough period after the cavities have been closed, to admit of the carbon in the adjacent steel being afforded the opportunity to reduce the oxide scale." Austin[6] melted samples of cast iron in a closed electric furnace and collected the evolved gases; they consisted chiefly of hydrogen plus nitrogen (which, unfortunately, were not determined separately), with 23 to 59 per cent. CO and some $CO_2$. The $CO_2$ was much more abundant in cast iron and mild steel than in crucible and medium-carbon steel. The amount of gas collected was least in cast iron and greatest in crucible steel.

*Effect of Different Constituents on Steel.*—Much work has been done on the equilibrium diagrams of Fe-FeS and Fe-MnS in past years[20] and this has been of advantage in the important question of sulphur in steel. Becker[1] and Loebe continued the Fe-FeS investigation, while Roehl made a great stride in advance by studying the system FeS-MnS. He finds a new constituent, $Fe_3Mn_2S_5$, which melts at 1360° C., as compared with 1188° C. for FeS and 1620° C. for MnS. It is evident that the double sulphide will enable the desulphurizing action of metal mixers to take place more easily than the sulphide or manganese would do, and also that the double sulphide enables a small amount of sulphur to exert a greater effect on the steel than it would in the form of MnS. Charpy and Bonnerot[2] show that hydrogen rapidly permeates steel at all temperatures above 350° C. and that nascent hydrogen has a special chemical activity in diffusion. Sieverts[12,6] finds that the solubility of melted iron for hydrogen increases proportionately with the temperature, and also increases suddenly when the metal melts. On solidifying, iron gave up seven volumes of hydrogen. De Nolly and Veyret[2] state that many substances used for carbonizing steel disengage hydrogen on heating, and that it is absorbed hydrogen which causes cemented steel to be so often fragile and to have coarse-grained, brittle cores. Andrew[6] finds that iron and steel absorb nitrogen when melted under a high pressure of the gas; that 0.3 per cent. nitrogen entirely suppresses the critical changes of pure iron; that 0.25 per cent. nitrogen markedly lowers the $Ar_1$ point of a steel containing 0.6 per cent. carbon, and that this steel could only be freed from nitrogen by several weeks' heating *in vacuo*.

The use of about 0.25 to 0.30 per cent. of copper in steel for rails attracted a good deal of notice and the results of service tests of these rails is awaited with much interest. Steel tubes also were made with

copper up to about 0.50 per cent. with the expectation of benefitting by the increased resistance to corrosion of such cupreous steel. The difficulty of welding such steel has, however, militated against its more extensive use.

*Properties and Uses of Cast Iron.*—One of the most important investigations on charcoal cast iron ever published appeared in 1912 from the pen of J. E. Johnson, Jr.[3]: By means of complete chemical analysis, metallographic examination, and, finally, the assignment of each grade of iron to its proper place in the iron-carbon equilibrium diagram, he determined some of the factors which produce good and bad charcoal iron, and also gave us the first satisfactory explanation of the cause of cast iron with a white center and gray exterior. This "spotted iron" is often found in the Swedish product and may be produced from almost any iron not too high or too low in silicon by pouring it into sand at a low temperature. Herbert E. Field had explained its cause on the ground of pressure, as follows: The interior, which is still liquid after the exterior has solidified, is put under such pressure (by the separation of graphite from the exterior shortly after its solidification) that the interior cannot separate graphite when it reaches the appropriate point to do so.

Johnson pointed out that, if this were the only cause, then all irons would be white inside. Johnson found, however, that the white center is a eutectic of iron and carbon, and that the action occurs more readily in hyper- than in hypo-eutectic irons. Since these "spotted irons" are low in quality, and are often troublesome in foundry practice—especially in malleable foundries—this observation is of real practical value. Rugan[6] and Messerschmitt[6] continued the study of growth of cast iron on heating and cooling, and Campbell and Glassford[5] extended these studies to the problem of the failure of cast-iron fittings for superheated steam and show that the difficulty is caused partly by growth and partly by oxidation between the grains of the iron. Von Emperger[1] suggested using cast iron for reinforced-concrete columns, instead of steel. He found that a cast-iron column, 14 cm. in diameter and 3 m. long was increased in strength from a breaking load of 137 tons to a breaking load of 321 tons by a covering of concrete 29 mm. thick. Schoettler[18] gave a valuable series of tests of cast iron of different sections.

The Mayari iron ore of Cuba, after nodulizing, contains about 55 per cent. iron, 13 per cent. alumina, 2 per cent. chromium, and 1 per cent. nickel plus cobalt. These ores can be smelted in blast-furnaces, either alone or with other ores, and produce a pig iron containing up to nearly 3 per cent. chromium and 1.5 per cent. nickel. It was discovered by accident, according to Bent,[10,16] that this Mayari iron could be mixed

with other irons to make a superior quality of casting as regards wear, strength, finish and closeness of grain. It is now in much demand for chilled castings and others of excellent strength or finish.

*Welding of Steel.*—Bermann[5] tells us that an oxidizing flame should be used for heating surfaces that are to be welded, lest otherwise the steel take up carbon from the coal. The spark test, he says, is the best method of learning whether such an absorption has occurred, and the best mechanical test is to bend the weld to and fro at a red heat, unless it is a question of passing acceptance tests, when alternate torsion or bending at ordinary temperatures should be applied. Finally, he concludes that the presence of manganese in the steel is favorable, because it reduces the crust of oxides. As to autogenous welding, he concludes that a reducing flame is the better and that the material melted should have the same composition as the pieces to be welded together; then, if the spark test is applied to test absorption of carbon, the weld should have the same character as the welded pieces. In this latter opinion, Bermann is contradicted by Stanton and Pannell[6], who found that welds made by the oxyacetylene process were not comparable with those made by either the hand or the electric process. Perhaps the spark test would have revealed the reason for the inferiority of the autogenous welds they tested. As to hand and electric welding, Stanton and Pannell found that hand welding gave substantially the same result as electric welding for iron, namely, 89 per cent. efficiency, while electric welding of steel gave much better results than hand welding, 93 per cent. and 82 per cent., respectively. A new process for the welding of tubes from skelp consists in heating only the edges that are to be united, by means of the oxyacetylene flame, thus avoiding heating about 80 per cent. of the skelp unnecessarily. The process of "flameless combustion" is suggested as a still cheaper means of accomplishing the same result.

*Heat Treatment of Steel.*—Sauveur[5] discovered that if soft steel be subjected to a certain critical strain, it makes it especially liable to growth of the grains during subsequent heating for a long time at low temperatures. This observation is of importance in connection with the manufacture and use of steel tie-rods for furnaces, etc. Portevin and Bernard[2] found that events which might occur during the forging of steel will produce the structure known as "Widmanstätten's." These events are: Too long sojourn in the zone where austenite is normal, and too rapid cooling during the separation of ferrite or cementite, *i.e.*, during secondary crystallization. Belaiew[14,1,2] has contributed a study of the crystallization of steel, and of the Widmanstätten structure, which has caused the Russian artillery to announce that the visibility of the Widmanstätten structure at any magnification up to 50 diameters

is sufficient cause for rejecting the material. Belaiew states that the primary crystallization of steel consists of dendrites built up of octahedrons, and that these dendrites can be seen with the naked eye after prolonged attack with acids; furthermore, that the austenite region of the iron-carbon equilibrium diagram is the zone of granulation, and this granulation may be revealed by attack with hydrochloric acid at high temperatures; the secondary crystallization is affected by the preceding events, he says, and, with rapid secondary crystallization, we get the Widmanstätten structure. Belaiew further says[2] that macroscopic examination is useful for telling us the stable structure of steel, while microscopic examination discovers more the events of recent heat treatment. Haneman[1] and Steinberg[13,2] discussed the refining of steel by heat treatment; Sherry[7] studied the coarse crystallization of soft steel and Oberhoffer[1,10] treats ably of the refining and annealing of steel castings.

Sauveur and Rheinhardt[3] suggested that, since some alloy steels are normally in the pearlitic condition at atmospheric temperatures when the carbon in them is low, and the same steels will be normally in the martensitic or austenitic condition at the same temperatures when the carbon is high, that we may case harden such steels without quenching, by simply carbonizing the outer layers. Giolitti[1] continued his exhaustive studies of cementation and announces that he has found that carbon alone can cement steel, but weakly. The researches of Charpy and Bonnerot[2] contradicted this statement and corroborate the earlier investigations of the same authors to the effect that, near 950° C., solid carbon cannot penetrate steel or iron without having a gaseous vehicle. Abbott[3] and Guillet[23,10] gave us some useful data upon the best carbonizing materials and methods to use with different articles to be cemented; Lothrop[15] studied the effect of several variables; Nead and Bourg[10] discussed the time required for heating various carbonizing substances, and Ammon[1] developed a test, which is a combination of the Brinell and Shore tests, to tell the depth to which effective hardening has extended. A French process of partial carbonizing, which is said to be new, consists in covering part of the surface with some metal like copper or nickel, to prevent the carbon penetrating there, and thus getting surfaces which are case hardened in some places and soft in others.[8] In order to avoid explosions in carbonizing practice, de Nolly and Veyret[2] studied the gases disengaged by various carbonizing materials: They found that there is much evolution of gas between 300 and 700° C., and that this gas consists chiefly of hydrogen, carbon monoxide, hydrocarbons and nitrogen. It is the hydrogen, they say, that causes cemented steel to be so fragile. To avoid explosions, they advise heating very slowly to 700°, avoiding

animal and vegetable cements in favor of wood charcoal mixed with 30 to 50 per cent. of carbonate of barium.

*Alloy Steels.*—Boudouard[2] investigated the electric resistance of special steels and Clamer[6] patented a white, non-corrosive alloy containing 65 per cent. iron, 25 per cent. nickel and 10 per cent. copper, with 0.2 per cent. carbon. It is said to have the following admirable physical properties: tensile strength, 96,100 lb. per square inch; elastic limit, 51,750 lb. per square inch: elongation in 2.0 in., 42 per cent.; reduction of area, 53.7 per cent. Campredon[8] described some improvements and new uses of vanadium steels, and the effect of vanadium in tool steel was extensively discussed.[10] Novelties on the heat treatment of chromium steels were also described.[10] New uses for titanium steel continue to be found, and doubtless over 1,000,000 tons of this "cleansed" material were made in 1912.

A new and natural alloy of iron, nickel and chromium attracted much attention in 1912, and is sold under the name of "Mayari steel." It consists of pig iron smelted from the Mayari ores of Cuba and then purified in an open-hearth furnace. A steel is produced containing phosphorus and sulphur below 0.04 per cent. each; manganese, 0.50 to 0.80 per cent.; nickel, 1.00 to 1.50 per cent. and carbon and chromium varying according to the grade of hardness desired, from 0.25 to 0.50 per cent. carbon, and from 0.10 to 0.40 per cent. chromium. Vanadium and titanium are sometimes used in combination with these alloys. The Mayari steel is used wherever an extraordinary combination of strength or hardness with ductility is desired; after appropriate heat treatment, it may have an elastic limit of nearly 200,000 lb. per square inch with an elongation in 2.0 in. of 10 per cent. and a reduction of area of 32 per cent., or else, we may get an elastic limit of nearly 100,000 lb. per square inch with an elongation of 25 per cent. and reduction of area of 65 per cent. This remarkable steel has been used for track bolts, heat-treated eye-bars, railroad rails, crankshafts, axes, tools, springs, etc. On account of its nickel and chromium it is especially adapted to case-hardened articles.

*Blast-furnace Improvements.*—Johnson[3,10,16] devised a blast-furnace construction in which four columns, set well out from the furnace, support four I-beams, which in turn support the stack itself by means of brackets. This not only gives much better access to the furnace bosh, but saves important time in the building of the furnace after a shutdown. The thin-lined furnace is gradually finding its appropriate place in the manufacture of pig iron. Some furnaces have been built with linings too thin—9 in. is not sufficient for the demands of daily service and 12 in. is probably about the correct mean. Some[21] even go so far as to say that this type of furnace has not really come to stay.

Recent changes in blast-drying apparatus tend to cheaper costs for installation; one of the latest of these is a two-stage process, whereby the air is cooled by water in an outer, annular ring of the drying chamber, and then cooled further by direct contact with cold brine in the inner space. This method avoids the necessity for freezing out the moisture with subsequent de-frosting, and gives greater efficiency in cooling on account of direct contact, besides greatly cheapening the installation cost. European practice frequently enriches the blast with oxygen in varying amounts as needed, in order to accomplish the same regularity of conditions and heightening of hearth temperature over critical temperature, which the dried blast accomplishes. Lührman[1,10] reported the result of this practice at some of the furnaces: The oxygen is added in the form of enriched air, containing 50 per cent. oxygen and 50 per cent. nitrogen, which may be made at the furnace itself if desired. The cost appears to be about 50 cents per ton of iron made for oxygen enough to raise the temperature of the hearth by about 50° C. The granulation of slag by means of air instead of water has advantages where water is scarce or where it is desired to produce the granulated slag in a dry state.[21,10] Porter[3] suggests a new standard of cost keeping for blast-furnaces. His plan is to establish certain standards of efficiency and to judge the economy of operation by comparison of costs with these standards, instead of by an arbitrary comparison of figures which may be only confusing under different conditions of raw materials, labor, etc.

*Iron Foundry Changes.*—West[17] devised a method of producing chilled iron castings by sudden cooling with water instead of with metal "chills" placed in the sand mold. A German foundry has been mechanically charging its cupolas with a degree of success which contradicts the discredit cast upon this innovation by those who claimed that a uniform melting could not be thus obtained. The Germans also studied the problem of permanent moulds.[1] The regenerative open-hearth furnace has been used for some years for the manufacture of malleable cast iron on account of its greater control over the chemical reaction and the temperature and its lower cost for fuel and hearth repairs than the air fu nace; now an American foundry is installing an open-hearth furnace f making high-grade castings of gray iron.

*New Open-hearth Practice.*—The increasing price of oil and the gr ing production of tar on account of the increase in number of by-proc coke ovens, has caused tar again to become interesting to furnace agers as an open-hearth fuel. Important interests have taken this tice up and no doubt it will have many advocates. The idea is means new. Coke-oven gas is also rapidly growing as an open- fuel and there are more plants using the maximum amount of exc

for this purpose, and even using blast-furnace gas to heat the coke ovens in order to get more oven gas for the open-hearth furnaces. There is a new raw material for open-hearth furnaces which seems to have usefulness where coke, pig iron and scrap are high in price. This new material is an iron sponge, containing about 97 per cent. iron, 1.4 per cent. gangue and 1 per cent. oxygen. It is made by subjecting iron ore to a stream of carbon-monoxide gas at temperatures below the melting-point of iron. For localities where the smelting of iron is costly on account of lack of coke, and where carbon monoxide gas may be cheaply obtained from peat, oil, etc.—localities like California, for instance—this process would seem to have an important future. Carr[10,16] put in operation several open-hearth furnaces of small size, made with the hearth entirely inclosed in steel and so arranged that it can be picked up by a crane and used as a ladle to pour steel into moulds. The purpose is to save the loss of heat consequent upon pouring the steel from the furnace into a ladle, and the furnace is especially adapted to the manufacture of castings.

*Electro-metallurgy.*—Two new American foundries built electric furnaces for the manufacture of steel castings, and the Bethlehem Steel Co. is now installing a large furnace of the Girod type to super-refine the steel from its bessemer and open-hearth furnaces. This will make an important addition to our present electric steel-making furnaces, none of which has ever operated at anything approaching its maximum capacity. The electric melting of ferro-manganese, in order to add it as a recarburizer in the liquid condition, attracted much attention during 1912.[1,10] Some interesting details of the manufacture of high-grade ferro-silicon in the electric furnace also appeared,[7] and the cost of this manufacture is said to be less than the preliminary estimates made for it.[2] The smelting of iron ore progresses satisfactorily in California, and the pig iron produced is of good quality and can be made especially suitable for cheap conversion in the open-hearth furnace.[7,8,16] In Sweden the production of pig iron is increasing rapidly and much technical progress is being made with the process.[19,1] There are now about 70 electric furnaces in active operation, including both ore-smelting furnaces and steel-melting or refining furnaces.

*Miscellaneous Improvements in Steel Practice.*—The duplex process is to be extended to two more large American plants; in one case in connection with Talbot furnaces, and in the other with the usual type. The casting of small ingots has advantages where small products, like billets, are to be produced, but the mechanical difficulties of teeming and handling so many units are great. For instance, an ordinary, modern American open-hearth could produce about 75 ingots weighing a ton each, every time it made a cast. A German[1,10] and a French[2,10]

process for avoiding these difficulties were developed and put in practice in Europe. In the French system, the ingots are cast by the bottom-pour method in batteries; the ingot moulds are split, and a battery of moulds is held together by a pair of hydraulic presses. This cheapens the cost of stripping and setting up. In the German system, the ingots are also bottom-cast into moulds much like the ordinary type but having ears and keys, so that a whole battery of moulds can be handled at one time by a crane with suitable spreaders. The ingots are also handled in batteries by a similar device. Ingots as small as 150 lb. weight have thus been cast commercially. A new steel-casting converter has been installed in several foundries in Europe and America. Its novelty consists in means by which the pig iron for conversion can be melted with oil in the converter itself previous to each blow. The time of melting is said to be 1¼ hours. The advantages are the saving of heat and saving the cost of a cupola; the disadvantages are the waste of iron, irregularities in time of operation and heavy installation costs on account of the recuperative system employed. A process of rolling special shapes, such as hinges, wrenches, chain links, etc., instead of drop-forging, consists in cutting the dies in upper and lower roll and then having means to assure their coming above one another during rolling. It has been adopted by a German mill and is said to have several advantages.[10]

*A New Charcoal Iron Process.*—For some purposes, charcoal wrought iron is without an equal. It has long been made by the old crude process which is costly in comparison with the newer processes of iron and steel manufacture. Now a new process is being operated by a works near Philadelphia, and is said to have several advantages over the old process, notably cheaper working costs and greater uniformity and higher grade of product. An open-hearth furnace is used in this new method; this is first heated by oil or gas and then a layer of charcoal is spread on the hearth and the charge of pig iron placed on top of it. A layer of charcoal goes on top of the iron; then cold air from suitably placed tuyeres burns the charcoal, melts and boils the iron in the usual way. The melted metal trickles down through the lower layer of charcoal. More charcoal is added at intervals if needed, and is always added at the end to expel any gases that may arise. The impurities are oxidized by the cold blast in the usual way. A layer of slag intervenes between the iron and the charcoal on top of it. When the purification is complete, the liquid iron is tapped and poured into ingots. It is claimed to have exceptional purity and to be under better control because analyses can be made before the charge is removed from the furnace.

One of the largest manufacturers of wrought iron in America has installed and is operating the Roe puddling furnace and the results of continuous commercial operation are awaited with great interest.

[1] *Stahl u. Eisen*, 1912.
[2] *Revue de Métallurgie*, 1912.
[3] *Trans. A. I. M. E.*, 1912.
[4] *Trans. A. I. M. E.*, 1913.
[5] *Proceedings*, International Association for Testing Materials, 1912.
[6] *Journal, Iron and Steel Institute of London*, 1912.
[7] *Met. and Chem. Eng.*, 1912.
[8] *La Metallurgie*, 1912.
[9] *Physical Review*, 1912.
[10] *Iron Age*, 1912.
[11] *Iron and Steel Institute*, Carnegie Scholarship Memoirs, Vol. IV, 1912.
[12] *Zeit. für physikalische Chem*, Vol. LXXVII.
[13] *Journal* Russian Metallurgical Society.
[14] Annals of the Imperial Russian Technical Society.
[15] *Proc.*, American Society of Mechanical Engineers, 1912.
[16] *Iron Tr. Rev.*, 1912.
[17] *Trans.*, American Foundrymen's Association, 1912.
[18] *Zeit. des Vereins deutscher Ingeneure*, 1912.
[19] *Jernkotorets Annaler*, August, 1911, and March, 1912.
[20] *Metallographie*, 1909, 1910, 1911, 1912.
[21] *Eng. and Min. Journ.*, 1912.
[22] *Die Metallurgie*, Vol. IX, 1912.
[23] *Le Genie Civil*, Abs. in *Iron Age*, Apr. 11, 1912.
[24] *Proceedings*, Staffordshire Iron and Steel Institute, 1911.
[25] *Die Metallurgie*, 1911.
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# LEAD

The production of lead in the United States for the year 1912, as reported by the various refiners, was 410,006 tons as compared with 400,958 tons in 1911. These figures give the actual production of the various smelteries which treat lead ore and also of those which produce lead as a by-product. They represent the refinery production of lead in final marketable form. The large increase in the production of desilverized lead was due to the inauguration of smelting and refining by the International Company. Although the refinery had by the end of the year worked up nearly all of the accumulation of base bullion previously made at the smeltery, it is important to note that a large stock of ore had been accumulated at the smelting works previous to the beginning of 1912.

Included in the above figures is 4622 tons of lead derived from dross, scrap, etc., smelted and refined in works of which the principal business is the treatment of raw material.

In classifying the lead production of the United States we adhere to our old custom of grouping the smelters of southeast and southwest Missouri, although certain of them desilverize their lead.

While a small increase of lead production occurred in the Cœur d'Alene region, Idaho, and in Utah, a considerable falling off of production took place in Missouri, where the output was exceptionally large during 1911. New important sources of supply were not discovered in this country.

A formidable competitor of the American Smelting & Refining Co. for the smelting and refining of lead has arisen in the International Smelting & Refining Co., which commenced operations at its lead smeltery, at Tooele, early in 1912. Its refinery, which is situated at East Chicago, Ind., went into commission toward the latter part of the year.

METALLURGICAL PRODUCTION OF LEAD IN THE UNITED STATES.
(Refinery Statistics. In tons of 2000 lb.)

| Year. | Domestic Origin. | | | | | | Foreign Origin. | | Grand Total. |
|---|---|---|---|---|---|---|---|---|---|
| | Desilverized. | Antimonial | S. E. Mo. | S. W.Mo. | Miscel. | Total. | Desilverized. | Antimonial | |
| 1907... | 213,383 | 9,614 | 108,510 | 17,833 | 790 | 350,130 | 76,016 | (a) | 426,146 |
| 1908... | 174,650 | 13,109 | 113,103 | 18,014 | *Nil.* | 318,876 | 94,992 | (a) | 413,868 |
| 1909... | 211,499 | 10,392 | 126,784 | 20,489 | *Nil.* | 369,164 | 89,681 | 2,338 | 461,183 |
| 1910(b) | 217,490 | 9,098 | 145,387 | 20,729 | *Nil.* | 392,704 | 90,473 | 4,892 | 488,069 |
| 1911(b) | 211,041 | 8,916 | 155,008 | 25,993 | *Nil.* | 400,958 | 89,487 | 4,929 | 495,374 |
| 1912(b) | 236,207 | 9,239 | 145,336 | 19,224 | *Nil.* | 410,006 | 82,715 | 5,003 | 497,724 |

(a) Entered under domestic antimonial. (b) From *Eng. and Min. Journ.*

In the statistics given in the accompanying table, one smeltery in ansas is included in "Southwest Missouri" and two smelteries in Illinois e included in "Southeast Missouri," as most of their ore comes from ose districts.

STATISTICS OF LEAD IN THE UNITED STATES.

(In tons of 2000 lb.)

| ear. | Produced from Domestic Ores. | | | | Imported in Ores and Bullion. (c) | Total Production and Imports. | Exported in all Forms. (c) |
|---|---|---|---|---|---|---|---|
| | Desilverized. | Soft. (a) | Antimonial. (b) | Totals. | | | |
| 9.... | 171,495 | 40,508 | 7,377 | 217,085 | 76,423 | 317,196 | 74,944 |
| 0.... | 221,278 | 47,923 | 9,906 | 279,107 | 114,397 | 425,824 | 100,288 |
| 1.... | 211,368 | 57,898 | 10,656 | 279,922 | 112,471 | 458,033 | 100,026 |
| 2.... | 199,615 | 70,424 | 10,485 | 280,524 | 107,715 | 458,456 | 82,228 |
| 3.... | 188,943 | 78,298 | 9,453 | 276,694 | 106,407 | 418,601 | 81,971 |
| 4.... | 200,858 | 90,470 | 10,876 | 302,204 | 112,852 | 415,056 | 84,142 |
| 5.... | 205,665 | 105,623 | 11,186 | 322,474 | 98,378 | 420,852 | 59,741 |
| 6.... | 220,095 | 118,000 | 10,120 | 348,215 | 84,134 | 432,349 | 47,323 |
| 7.... | 213,383 | 127,133 | 9,614 | 350,130 | 79,815 | 429,945 | 51,502 |
| 8.... | 174,650 | 131,117 | 13,109 | 318,876 | 112,074 | 430,950 | 76,857 |
| 9.... | 211,499 | 147,273 | 12,730 | 371,502 | 114,181 | 485,683 | 86,077 |
| 0(d). | 217,490 | 166,116 | 13,990 | 397,596 | 108,602 | 506,198 | 69,786 |
| 1(d). | 211,041 | 181,001 | 13,845 | 405,887 | 89,951 | 495,838 | 101,787 |
| 2(d). | 236,207 | 164,560 | 14,242 | 415,009 | 83,560 | 498,509 | 64,905 |

(a) Since 1904 a large part of the so-called soft lead was desilverized, but this (being of Missouri gin) has been included in the old classification. (b) The entire production of antimonial lead is ered as of domestic production, although part of it is of foreign origin. (c) Includes "pigs, bars d old." (d) From *Eng. and Min. Journ.*

IMPORTS OF LEAD IN ORE, BASE BULLION, PIGS, BARS AND OLD. (a)

(In tons of 2000 lb.)

| Source. | 1904. | 1905. | 1906. | 1907. | 1908. (c) | 1909. (c) | 1910. (c) | 1911.(c) | 1912. (c) |
|---|---|---|---|---|---|---|---|---|---|
| ited Kingdom.... | 247 | 795 | 4,926 | 217 | (b) | (b) | (b) | (b) | (b) |
| rmany..... | 366 | 125 | 1,003 | 228 | (b) | (b) | (b) | (b) | (b) |
| ier European..... | 83 | 59 | 1,961 | 3,461 | (b) | (b) | (b) | (b) | (b) |
| ada..... | 8,952 | 8,182 | 9,257 | 6,663 | 644 | 2,063 | 60 | 68 | *Nil* |
| xico..... | 102,903 | 87,584 | 66,756 | 68,767 | 107,369 | 104,120 | 98,535 | 83,925 | 79,672 |
| th America..... | 290 | 1,577 | 158 | 442 | (b) | 915 | 3,289 | 2,383 | 1,603 |
| ier Countries..... | 11 | 56 | 74 | 63 | 1,273 | 3,507 | 3,233 | 943 | 2,013 |
| Total..... | 112,852 | 98,378 | 84,135 | 79,814 | 109,286 | 110,605 | 105,117 | 87,319 | 83,288 |

(a) Refined lead, *i.e.*, in pigs, bars and old, is a small part of the total. It was in 1904, 8,724 tons; 5, 5,720 tons; 1906, 11,763 tons; 1907, 9,277 tons; 1908, 2,759 tons. (b) Included in other coun- s. (c) Figures do not include imports of pigs, bars and old. With these the total imports for 8 and subsequent years were as stated in the table above.

PRODUCTION OF CRUDE LEAD BY STATES.
(In tons of 2000 lb.)

| State. | 1905. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|---|
| Arizona | 1,986 | 2,884 | 2,200 | 1,867 | 1,304 | 1,399 | 4,392 | 3,201 |
| California | 110 | 432 | 850 | 490 | 865 | 1,038 | 529 | 1,059 |
| Colorado | (*f*)57,856 | (*f*)52,992 | 47,332 | 26,707 | 26,413 | 34,711 | 28,730 | 33,196 |
| Idaho | (*h*)107,000 | (*i*)121,584 | 111,697 | 98,394 | 97,137 | 99,840 | 116,524 | 126,035 |
| Kansas | (*n*) | (*n*) | 1,800 | 2,400 | 1,500 | 1,343 | 2,500 | 162,194 |
| Missouri | (*g*)102,500 | 115,103 | 123,613 | 125,216 | 146,829 | 160,642 | 173,787 | |
| Montana | 2,097 | 2,485 | 2,005 | 2,309 | 1,331 | 1,795 | 2,492 | 2,517 |
| Nevada | 2,096 | 1,669 | 3,400 | 3,676 | 4,086 | 2,119 | 1,076 | 5,640 |
| New Mexico | 1,170 | 640 | 1,900 | 611 | 1,275 | 1,730 | 1,381 | 2,478 |
| Oklahoma | ..... | ..... | 400 | 1,000 | 3,000 | 1,860 | 1,950 | 2,500 |
| Utah | 42,746 | 56,260 | 54,738 | 43,995 | 65,975 | 57,158 | 54,538 | 59,317 |
| Wisconsin | ..... | 1,753 | 3,500 | 3,486 | 2,745 | 3,400 | 3,944 | 3,180 |
| Other States | (*k*)2,695 | (*m*)943 | 1,204 | 600 | 629 | 177 | 912 | 1,690 |
| Undistributed | ..... | ..... | ..... | 2,026 | 3,062 | 1,429 | 1,760 | |
| Zinc Smelters | ..... | ..... | 1,320 | 1,290 | 2,796 | 1,988 | 3,511 | 6,217 |
| Total | 320,256 | 356,745 | 355,959 | 314,067 | 358,947 | 370,629 | 398,026 | 409,224 |

Figures for 1904 and 1905 are by the U. S. Geological Survey giving production of "merchant lead." Figures for 1906 and subsequent years are from smelters' reports to the *Eng. and Min. Journ.* (*f*) Report of State Commissioner of Mines. (*h*) Partly estimated. (*i*) Report of State Inspector of Mines less allowance of 5 per cent. for loss in smelting. (*k*) Includees production of Alaska, Oregon, So. Dakota, Washington, Georgia, Tennessee, Virginia, Kentucky and Texas. (*m*) Includes production of Illinois, Iowa, Kentucky, Tennessee and Washington. (*n*) Included with Missouri.

*Imports and Exports.*—The imports of lead in 1912 as reported by the Bureau of Statistics were 9789 short tons in ore, valued at $393,500, 73,500 short tons in base bullion valued at $3,328,083, and 272 tons of refined lead valued at $19,917; a total of 83,561 short tons as compared with 89,952 in 1911, 108,607 in 1910, and 114,182 in 1909.

DELIVERY OF LEAD IN THE UNITED STATES.
(In tons of 2000 lb.)

| | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|
| Supply: | | | | | |
| Production desilverized | 269,642 | 301,180 | 307,963 | 300,528 | 318,922 |
| Production soft lead | 131,117 | 147,273 | 166,116 | 181,001 | 164,560 |
| Production antimonial lead | 13,109 | 12,730 | 13,990 | 13,845 | 14,242 |
| Imports foreign refined lead | 2,759 | 3,576 | 3,485 | 2,632 | 272 |
| Stock, domestic lead, Jan. 1 | (*e*)50,000 | (*e*)75,000 | (*e*)94,430 | (*e*) 80,000 | (*e*)80,000 |
| Foreign in bond, Jan. 1 | 12,897 | 18,462 | 12,695 | (*e*) 13,000 | 4,481 |
| Total supply | 479,524 | 558,221 | 598,679 | 591,006 | 582,477 |
| Deductions: | | | | | |
| Re-exports of foreign | 76,857 | 86,077 | 69,786 | 101,227 | 64,906 |
| Exports of domestic lead | *Nil.* | 6 | *Nil.* | *Nil.* | *Nil.* |
| Stock, domestic, Dec. 31 | (*e*) 75,000 | (*e*)94,430 | (*e*)80,000 | (*f*) 80,000 | (*f*)65,000 |
| Foreign in bond, Dec. 31 | 18,462 | 12,695 | (*e*)13,000 | (*e*) 2,000 | 10,492 |
| Total deductions | 170,319 | 183,208 | 162,786 | 183,227 | 75,398 |
| Delivery | 309,205 | (*e*)351,000 | (*e*)435,893 | 407,779 | 507,079 |

(*e*) Partly estimated. (*f*) Assumed.

LEAD PRODUCTION OF THE WORLD.
(In metric tons.)

| Year. | Australasia. (a) | Austria. (a) | Belgium (a) | Canada (a) | France. (a) | Germany (a) | Greece. (a) | Hungary (a) | Italy. (a) |
|---|---|---|---|---|---|---|---|---|---|
| 1899.. | 87,600 | 9,736 | 15,700 | 9,917 | 15,981 | 129,225 | 19,059 | 2,166 | 20,543 |
| 1900.. | 87,100 | 10,650 | 16,365 | 28,648 | 15,210 | 121,513 | 16,396 | 2,030 | 23,673 |
| 1901.. | 90,000 | 10,161 | 18,760 | 23,537 | 21,000 | 123,098 | 17,644 | 2,029 | 25,796 |
| 1902.. | 90,000 | 11,264 | 19,504 | 10,411 | 18,817 | 140,331 | 14,048 | 2,243 | 26,494 |
| 1903.. | 106,006 | 12,162 | 22,263 | 8,226 | 23,258 | 145,319 | 12,361 | 2,057 | 22,126 |
| 1904.. | 117,895 | 12,645 | 23,470 | 17,241 | 18,800 | 137,580 | 15,186 | 2,104 | 23,475 |
| 1905.. | 106,418 | 12,968 | 22,885 | 25,391 | 24,100 | 152,590 | 13,729 | 2,146 | 19,097 |
| 1906.. | 93,557 | 14,846 | 23,765 | 24,580 | 25,614 | 150,741 | 12,308 | 1,925 | 21,268 |
| 1907.. | 96,608 | 13,598 | 27,450 | 21,660 | 24,800 | 164,079 | 13,814 | 1,468 | 22,978 |
| 1908.. | 119,207 | 12,669 | 35,650 | 19,593 | 26,112 | 164,079 | 15,892 | 1,544 | 26,003 |
| 1909.. | 77,992 | 12,941 | 40,306 | 23,295 | 26,927 | 167,920 | 14,948 | 1,590 | 22,133 |
| 1910.. | 105,897 | 15,476 | 40,715 | 14,967 | 20,226 | 159,851 | 16,710 | 2,077 | 14,495 |
| 1911.. | 105,397 | 18,097 | 44,308 | 10,791 | 23.600 | 161,287 | 14,948 | 1,583 | 16,684 |
| 1912.. | 113,710 | ..... | ..... | 16,226 | ..... | ..... | ..... | ..... | 21,450 |

| Year. | Japan. (a) | Mexico. (a) | Russia. (a) | Spain. (a) | Sweden (a) | United Kingdom. (a) | | United States. | Totals. (f) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Foreign Ores. | Domestic Ore. | | |
| 1899. | 1,989 | 84,656 | 322 | 184,007 | 1,606 | 17,571 | 23,929 | 196,938 | 818,945 |
| 1900. | 1,877 | 63,827 | 221 | 172,530 | 1,424 | 10,738 | 24,762 | 253,204 | 849,168 |
| 1901. | 1,806 | 94,194 | 156 | 169,294 | 988 | 19,639 | 20,361 | 253,944 | 892,407 |
| 1902. | 1,644 | 106,805 | 225 | 177,560 | 842 | 9,113 | 17,987 | 254,682 | 901,970 |
| 1903. | 1,728 | (b) 94,181 | 106 | 175,109 | 678 | 14,900 | 20,278 | 256,138 | 916,896 |
| 1904. | 1,803 | (e) 95,010 | 90 | 185,862 | 589 | 6,888 | 20,155 | 278,634 | 957,427 |
| 1905. | 2,272 | (b)101,196 | 700 | 185,693 | 576 | 7,517 | 20,977 | 290,472 | 988,727 |
| 1906. | 4,305 | (b) 73,699 | 907 | 185,470 | 753 | 6,984 | 22,691 | 323,567 | 986,980 |
| 1907. | 3,067 | (b) 76,158 | 520 | (d)185,800 | 813 | 10,880 | 24,850 | 322,854 | 1,010,605 |
| 1908. | 2,910 | (b)127,010 | 523 | 188,062 | 277 | 11,480 | 21,336 | 284,858 | 1,057,205 |
| 1909. | 3,429 | 118,186 | (d) 790 | 179,993 | 166 | 8,056 | 22,822 | (g)334,832 | 1,056,326 |
| 1910. | 3,907 | 120,662 | (d)1,200 | 190,523 | 355 | 8,933 | 21,866 | (g)355,183 | 1,093,144 |
| 1911. | 4,160 | 124,605 | (d)1,000 | 149,540 | 1,134 | 10,048 | 18,278 | (g)363,829 | 1,069,289 |
| 1912. | 3,613 | ..... | ..... | ..... | 1,073 | (e) 8,255 | 17,806 | (g)372,056 | ..... |

(a) From official reports of countries unless otherwise denoted. (b) Exports. (d) As reported by Metallgesellschaft, Frankfurt am Main. (e) Estimated. (f) The totals may be high on account of duplications which cannot be eliminated. (g) From *Eng. and Min. Journ.*

## Lead Markets in 1912

*New York.*[1]—The year opened with lead quoted at 4.45 cents., New York, and 4.32 .5 @ 4.35 cents, St. Louis. It remained on that basis until the end of January, when suddenly, on the 30th of that month, the American Smelting & Refining Co. reduced its published quotations by $4 a ton. Naturally, all other sellers of pig lead met these prices, giving the market a rather unsettled appearance, which again found its expression in a further reduction by the principal interests on Feb. 3 of $3, and shortly thereafter another reduction of $2 per ton was made, thus bringing the market to a level of 4 cents, New York, and 3.85 @ 3.90 cents., St. Louis. On that basis a large business was done by the A. S. & R. Co., which thus was enabled to move off the largest part of its accumulation, outside sellers not being willing to meet the decline.

[1] *Eng. and Min. Journ.*, Jan. 11, 1913.

On March 19, the market was advanced to 4.10 cents, New York; and on March 22 to 4.20 cents, when, due to reluctance by outside sellers to meet these prices and to speculative purchases of St. Louis lead, the St. Louis market advanced to the New York level.

The market remained stationary until the middle of June, when a very large demand developed, especially for white-lead purposes, and heavy orders were placed. On the 12th of that month, the American Smelting & Refining Co. advanced its price to 4.50 cents, New York. Business continued excellent and a further advance was made on July 3, to 4.75 cents, New York. At this level outside producers became very anxious sellers, freely cutting prices quoted by the American Smelting & Refining Co. Consequently, the latter was forced, in order not to lose its market entirely, to reduce the quotation, which it did on Aug. 5 to 4.5 cents, New York. At that time a great scarcity of lead developed in the European markets, which, in consequence thereof, were extremely strong, and advanced by leaps and bounds, so much so that the danger of exports from this country became imminent. Here also the demand remained not only very good, but increased constantly, and on Aug. 26, advances to 4.65 cents, on Aug. 30 to 4.85 cents, and on Sept. 9 to 5,10 cents were the result. Even at this very high level, no cessation of purchases was noticeable.

About the end of October and beginning of November, stocks accumulated in the West, which the owners were offering at considerable discounts. At that time also the International Smelting & Refining Co. appeared as a seller of lead. The consumption of the metal, as is usual at this season of the year, had become smaller, and thus the offers of this outside lead were not readily taken up. Quotations declined rapidly, being reduced, on Nov. 4, to 4.75 cents; Nov. 21 to 4.5 cents, and on Dec. 3 to 4.35 cents.

*London.*—Prices in 1912 opened fractionally better, and were well maintained by the scarcity of available supplies. Business was moderate in volume, and fluctuations narrow. Dealers were alert to secure purchases for extended delivery at the few shillings per ton less than was asked for prompt delivery. Closing prices were £15 10s. @ £15 12s. 6d. for Spanish.

Trade requirements being quite up to the normal, and incoming supplies insufficient, prices tended upward throughout February. Floods in Spain impeded the loading of vessels, and the arrival of the metal from the mines. Up to £15 18s. 9d. was paid for prompt delivery, but the scarcity was somewhat relieved as the month advanced. Business for forward delivery extended into May. Closing prices were £15 15s.@ £15 17s. 6d.

In March, shortage of fuel at the Spanish ports increased the difficulty of engaging freight thence, and the scarcity of lead for early delivery was sometimes acute. A strike of coal miners throughout the United Kingdom tended to restrict consumption, but manufacturers could foresee a large expansion of business and were alert to cover prospective requirements. Fluctuations were unimportant, and closing prices were £16 @ £16 2s. 6d.

The coal strike and the Easter holidays over, there was an active resumption of business in April, and the market was firm throughout the month, prices advancing gradually, and extra prices being paid occasionally for early delivery. Closing prices were £16 8s. 9d.@£16 10s. for foreign brands, and £16 12s. 6d.@£16 15s. for English.

May business was about normal as regards volume, and with few fluctuations. Toward the close, prices stiffened somewhat on the rumor of labor troubles threatening to restrict supplies from North America and from Spain, political unrest in Mexico operating similarly. The close was at £16 12s. 6d.@£16 13s. 9d.

Prices advanced steadily throughout June, an excellent home trade coinciding with speculative enterprise extending some months ahead. All incoming supplies were readily absorbed. Closing prices were £18 2s. 6d.@£18 5s. for foreign, and £18 7s. 6d.@£18 10s. for English.

In July, fluctuations were numerous, but mainly upward. Home trade was intermittent, but continental consumption was brisk, and American reports favorable. Labor trouble in the Port of London tended to restrict supply, and some high prices were paid for prompt delivery. The close was at £18 15s.@£18 17s. 6d.

The general expansion of trade was such that incoming supplies of lead were quite inadequate in August, and up to £1 per ton premium was paid in some instances for prompt delivery. Prices advanced generally, closing at £19 15s. for foreign (plus 15s. for early delivery), and £20@£21 for English.

The advance continued in September, and so acute was the scarcity that £23 15s. was at one time paid for prompt delivery. Thereafter, some relief was afforded by supplies arriving, and prices eased accordingly; but European trade demand was sufficient to arrest any important decline. Closing prices were £21@22 for foreign brands, according to time of delivery, and £22@23 for English.

In October, the threatened war in southeastern Europe induced general commercial depression, and its eventual outbreak caused prices to relapse heavily, more especially as supplies of the metal were now coming in abundantly. With transitory rallies prices drifted down to £18 15s.@£19 for foreign, and £19 5s.@£19 10s. for English. Consumers operated

cautiously in November, and holders had to accept reduced prices which, in turn, revived the demand, particularly for export. Down to £18 was occasionally accepted for early delivery, while £18 12s. 6d. was paid for February and March. Monetary stringency operated in holding prices down, but the intrinsic position of the article was sound, and producers had difficulty in fulfilling their engagements. The close was at £18@£18 3s. 9d. for foreign, and £18 7s. 6d.@£18 12s. 6d. for English lead.

In December, consumption demand was good, but the threatened political complications kept prices down and even depressed them a little, though the fluctuations were small. The year closed with £17 17s. 6d. quoted for Spanish lead, with English 5s. higher.

AVERAGE MONTHLY PRICE OF LEAD PER POUND IN NEW YORK.

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *Cts.* |
| 1899... | 4.18 | 4.49 | 4.37 | 4.31 | 4.44 | 4.43 | 4.52 | 4.57 | 4.58 | 4.58 | 3.70 | 4.64 | 4.47 |
| 1900... | 4.68 | 4.68 | 4.68 | 4.68 | 4.18 | 3.90 | 4.03 | 4.25 | 4.35 | 4.35 | 4.58 | 4.35 | 4.37 |
| 1901... | 4.35 | 4.35 | 4.35 | 4.35 | 4.35 | 4.35 | 4.35 | 4.35 | 4.35 | 4.35 | 4.35 | 4.15 | 4.33 |
| 1902... | 4.00 | 4.075 | 4.075 | 4.075 | 4.075 | 4.075 | 4.075 | 4.075 | 4.075 | 4.075 | 4.075 | 4.075 | 4.069 |
| 1903... | 4.075 | 4.075 | 4.442 | 4.567 | 4.325 | 4.210 | 4.075 | 4.075 | 4.243 | 4.375 | 4.218 | 4.162 | 4.237 |
| 1904... | 4.347 | 4.375 | 4.475 | 4.475 | 4.423 | 4.196 | 4.192 | 4.111 | 4.200 | 4.200 | 4.200 | 4.600 | 4.309 |
| 1905... | 4.552 | 4.450 | 4.470 | 4.500 | 4.500 | 4.500 | 4.524 | 4.665 | 4.850 | 4.850 | 5.200 | 5.422 | 4.707 |
| 1906... | 5.600 | 5.464 | 5.350 | 5.404 | 5.685 | 5.750 | 5.750 | 5.750 | 5.750 | 5.750 | 5.750 | 5.900 | 5.657 |
| 1907... | 6.000 | 6.000 | 6.000 | 6.000 | 6.000 | 5.760 | 5.288 | 5.250 | 4.813 | 4.750 | 4.376 | 3.658 | 5.325 |
| 1908... | 3.691 | 3.725 | 3.838 | 3.993 | 4.253 | 4.466 | 4.477 | 4.580 | 4.515 | 4.351 | 4.330 | 4.213 | 4.200 |
| 1909... | 4.175 | 4.018 | 3.986 | 4.168 | 4.287 | 4.350 | 4.321 | 4.363 | 4.342 | 4.341 | 4.370 | 4.560 | 4.273 |
| 1910(a | 4.700 | 4.613 | 4.459 | 4.376 | 4.315 | 4.343 | 4.404 | 4.400 | 4.400 | 4.400 | 4.442 | 4.500 | 4.446 |
| 1911(a | 4.483 | 4.440 | 4.394 | 4.412 | 4.373 | 4.435 | 4.499 | 4.500 | 4.485 | 4.265 | 4.298 | 4.450 | 4.420 |
| 1912(a | 4.435 | 4.026 | 4.073 | 4.200 | 4.194 | 4.392 | 4.720 | 4.569 | 5.048 | 5.071 | 4.615 | 4.303 | 4.471 |

(a) From *Eng. and Min. Journ.*

AVERAGE MONTHLY PRICE OF LEAD PER 2240 LB. AT LONDON. (a)
(In pounds sterling.)

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1899.... | 13.375 | 14.350 | 14.150 | 14.375 | 14.146 | 14.283 | 14.385 | 14.733 | 15.267 | 16.179 | 17.096 | 16.883 | 14.933 |
| 1900.... | 16.296 | 16.542 | 16.612 | 16.733 | 16.900 | 17.225 | 17.533 | 17.633 | 17.667 | 17.596 | 17.229 | 16.233 | 16.987 |
| 1901.... | 15.925 | 14.667 | 13.379 | 12.421 | 12.275 | 12.342 | 12.150 | 11.692 | 11.954 | 11.600 | 11.267 | 10.533 | 12.521 |
| 1902.... | 10.567 | 11.617 | 11.508 | 11.596 | 11.600 | 11.271 | 11.233 | 11.121 | 10.892 | 10.746 | 10.717 | 10.754 | 11.262 |
| 1903.... | 11.304 | 11.708 | 13.225 | 12.404 | 11.800 | 11.437 | 11.383 | 11.146 | 11.167 | 11.108 | 11.108 | 11.179 | 11.579 |
| 1904.... | 11.558 | 11.592 | 12.037 | 12.254 | 11.754 | 11.521 | 11.667 | 11.737 | 11.787 | 12.187 | 12.892 | 12.775 | 11.983 |
| 1905.... | 12.875 | 12.462 | 12.296 | 12.658 | 12.762 | 13.000 | 13.608 | 13.958 | 13.950 | 14.679 | 15.337 | 17.050 | 13.719 |
| 1906.... | 16.850 | 16.031 | 15.922 | 15.959 | 16.725 | 16.813 | 16.525 | 17.109 | 18.266 | 19.350 | 19.281 | 19.609 | 17.370 |
| 1907.... | 19.828 | 19.531 | 19.703 | 19.975 | 19.688 | 20.188 | 20.350 | 19.063 | 19.775 | 18.531 | 17.281 | 14.500 | 19.034 |
| 1908.... | 14.469 | 14.250 | 13.975 | 13.469 | 12.938 | 12.600 | 13.000 | 13.375 | 13.125 | 13.375 | 13.538 | 13.156 | 13.439 |
| 1909.... | 13.113 | 13.313 | 13.438 | 13.297 | 13.225 | 13.031 | 12.563 | 12.475 | 12.781 | 13.175 | 13.047 | 13.125 | 13.042 |
| 1910.... | 13.650 | 13.328 | 13.063 | 12.641 | 12.550 | 12.688 | 12.531 | 12.513 | 12.582 | 13.091 | 13.217 | 13.197 | 12.920 |
| 1911.... | 13.009 | 13.043 | 13.122 | 12.889 | 12.984 | 13.260 | 13.530 | 14.260 | 14.744 | 15.332 | 15.821 | 15.648 | 13.970 |
| 1912.... | 15.597 | 15.738 | 15.997 | 16.331 | 16.509 | 17.588 | 18.544 | 19.655 | 22.292 | 20.630 | 18.193 | 18.069 | 17.929 |

(a) The statistics for 1897–1905 are from the report of the Metallgesellschaft, Frankfurt-am-Main. Those for subsequent years are from the *Eng. and Min. Journ.*

## Lead Pigments in 1912[1]

The opening months of 1912 did not promise any improvement over he disappointing volume of business in paints during 1911. There was, owever, a rapid revival beginning late in March, and trade during the emainder of the year was almost uniformly in excess of that of the orresponding months of 1911. While linseed oil, which is an impor- ant factor in the cost of paints, was not so high as it was in 1911, it was till above the average of the last 10 years, but the cost of materials or abor does not appear to have been high enough to put any check upon ainting either on old or new work, and the demand for all classes of aints was large. In spite of continued aggressive competition from he cheaper pigments, the production and sale of white lead show a eady increase which corresponds closely with the growth of the country.

There were 14 "official" price changes made by the smelting com- anies on pig lead during the year, the lowest price being in February, om which date to early September there was an advance of $22 per ton, he extreme high figure continuing into November, or nearly 2 months. fter that date the price declined $15 per ton. The extreme advance as not met by a corresponding rise on any of the lead pigments.

The deliveries of dry white lead during the first half of the year were argely on contracts entered into prior to Jan. 1, at 5@5 1/8 cents. The enewal of these contracts for the last half year was mainly at 5 3/8 cents, ut outside of these deliveries new business was at a price more closely pproaching the cost of the metal, and at one time as high as 6 cents as quoted by corroders. Following the course of pig lead there was a lecline during the last 2 months and at the close, contracts for next year ere made on the basis of 5 1/4 cents. The erratic course of the metal narket during 1912, however, rendered corroders chary of long-time ontracts, and few of them are now willing to go beyond 4 months, which s as far ahead as they can cover.

White lead in oil was quoted at 6 3/4@ 7cents per lb. at the opening of he year, but advanced $5 per ton late in June, and another $5 early in uly, following the rapid rise in pig lead. With the decline in the latter nd a lower price for linseed oil, a reduction of $10 per ton was made in November, and the close was at the opening price of the year, 6 3/4@7 ents. The demand for lead oxides from the chief consuming industries as good throughout the year, and prices were steadier than during the wo or three preceding years, although the margin over pig lead, taking he whole year through, was close. In litharge, the bulk of the business ith the heavy consumers was at from 5 3/8 cents early in the year to

[1] *Eng. and Min. Journ.*, Jan. 11, 1913.

5 3/4 cents toward the close, with 6@6 1/4 cents the prevailing figure during the period of the extreme high prices of pig lead. The closing price was 5 1/2@5 3/4 cents.

Red lead in the grades most in demand for industrial purposes ranged from 6 1/4@6 3/4 cents, following the course of pig lead, but in no case fully meeting the advance in the metal.

PRODUCTION OF LEAD PIGMENTS IN THE UNITED STATES.

| Year. | Red Lead. | | White Lead. (a) | | Litharge. | | Orange Mineral. | |
|---|---|---|---|---|---|---|---|---|
| | Short Tons | Value. | Short Tons. | Value. | Short Tons. | Value. | Short Tons. | Value. |
| 1899... | 10,199 | $1,070,895 | 103,466 | $10,812,197 | 10,020 | $1,032,060 | 928 | $ 139,200 |
| 1900... | 10,098 | 1,050,192 | 96,408 | 9,910,742 | 10,462 | 1,067,124 | 825 | 100,650 |
| 1901... | 13,103 | 1,448,550 | 100,787 | 11,252,653 | 9,460 | 979,586 | 1,087 | 224,667 |
| 1902... | 11,669 | 1,262,712 | 114,658 | 11,978,172 | 12,755 | 1,299,443 | 867 | 138,349 |
| 1903... | 12,300 | 1,385,900 | 112,700 | 12,228,024 | 12,400 | 1,326,800 | 1,000 | 168,000 |
| 1904... | 13,938 | 1,672,569 | 126,336 | 13,896,913 | 12,487 | 1,248,691 | 1,125 | 168,681 |
| 1905... | 16,269 | 1,919,767 | 122,398 | 12,068,443 | 12,643 | 1,422,616 | 1,000 | 120,000 |
| 1906... | 13,693 | 1,874,448 | 123,640 | 15,234,990 | 13,816 | 1,890,050 | 2,927 | 421,488 |
| 1907... | 13,370 | 1,778,717 | 111,409 | 12,254,297 | 14,769 | 1,624,553 | 815 | 123,917 |
| 1908... | 11,358 | 1,156,282 | 116,628 | 10,515,315 | 12,254 | 1,231,206 | 393 | 43,157 |
| 1909... | 15,800 | 1,438,197 | 131,643 | 12,652,638 | 13,391 | 1,266,903 | 530 | 68,003 |
| 1910 (b) | 16,116 | 1,482,672 | 134,276 | 13,024,762 | 13,659 | 1,283,940 | 541 | 70,330 |
| 1911 (b) | 19,594 | 2,345,520 | 132,612 | 17,393,241 | 25,190 | 2,733,196 | 766 | 119,370 |
| 1912 (b) | 21,120 | 2,571,702 | 146,833 | 18,683,461 | 29,111 | 3,194,194 | 545 | 88,245 |

(a) The output of "sublimed white lead," a mixed sulphate and oxide of lead, is not included in 1904–10. (b) U. S. Geol. Surv.

IMPORTS OF LEAD PIGMENTS INTO THE UNITED STATES

| Year. | Red Lead. | | White Lead. | | Litharge. | | Orange Mineral. | |
|---|---|---|---|---|---|---|---|---|
| | Pounds. | Value. | Pounds. | Value. | Pounds. | Value. | Pounds. | Value. |
| 1898..... | 682,449 | $25,780 | 506,739 | $24,334 | 56,417 | $2,021 | 795,116 | $37,745 |
| 1899..... | 776,197 | 30,479 | 583,409 | 30,212 | 55,127 | 3,614 | 1,141,387 | 58,142 |
| 1900..... | 549,551 | 25,532 | 456,872 | 28,336 | 77,314 | 2,852 | 1,068,793 | 61,885 |
| 1901..... | 485,466 | 19,369 | 384,671 | 21,226 | 49,306 | 1,873 | 977,644 | 52,409 |
| 1902..... | 1,075,839 | 37,833 | 506,423 | 25,320 | 88,115 | 2,908 | 997,494 | 49,060 |
| 1903..... | 1,152,715 | 40,846 | 453,284 | 24,595 | 42,756 | 1,464 | 756,742 | 36,407 |
| 1904..... | 836,077 | 30,115 | 587,383 | 33,788 | 44,541 | 1,500 | 766,469 | 37,178 |
| 1905..... | 704,402 | 26,553 | 597,510 | 34,722 | 117,759 | 4,139 | 628,003 | 31,106 |
| 1906..... | 1,093,619 | 50,741 | 647,636 | 41,233 | 87,230 | 3,737 | 770,342 | 42,519 |
| 1907..... | 679,171 | 35,959 | 584,309 | 37,482 | 90,475 | 4,386 | 615,015 | 37,799 |
| 1908..... | 645,073 | 28,155 | 540,311 | 30,451 | 96,184 | 3,327 | 485,407 | 26,645 |
| 1909..... | 760,179 | 30,428 | 694,599 | 39,963 | 90,655 | 3,740 | 496,231 | 27,562 |
| 1910..... | 822,289 | 32,750 | 686,052 | 38,919 | 48,693 | 2,252 | 600,461 | 32,199 |
| 1911..... | 1,163,533 | 46,170 | 741,071 | 46,213 | 24,662 | 1,196 | 504,734 | 28,515 |
| 1912..... | 757,908 | 33,854 | 687,705 | 46,494 | 32,443 | 1,550 | 334,551 | 20,914 |

## LEAD MINING IN THE UNITED STATES

*Arizona.*—The Copper Queen mine, in 1912, produced, in addition to its copper output, 11,626 tons of ore which, when smelted at the Phelps-Dodge plant at Bisbee, yielded 1477 tons of lead containing 326,962 oz. silver. A recent discovery of lead ore was made on the Iron Prince claim of the Shattuck mine, in close association with previously developed copper ore. The London-Arizona company is beginning ship-

ment of lead ore to El Paso from its O'Carroll claim at Christmas. The ore occurs on both sides of a porphyry dike cutting limestone, and is reported to average 35 per cent. lead and $2.50 in silver. The total lead output of the State in 1912 was 30 per cent. less than in 1911.

*California.*—The lead output of 1912 was approximately the same as for 1911, and is estimated at 550 tons, contributed largely by the lead-silver mines of Inyo County.

*Colorado.*—According to statistics of the State Bureau of Mines, the output of lead in 1912 was 36,689 short tons, valued at $3,280,703, an increase of 12 per cent. over that of 1911. The Leadville district was the leading producer, followed by Aspen, Creede, and the San Juan district. At Leadville, practically all the lead is derived from mixed ores of lead, zinc and manganese, all containing gold and silver. The largest producers on Carbonate Hill are the Star Consolidated, the Western, and the Castle View, the combined output of which is about 600 tons per day. In California Gulch, the large producers are the Yak, the Iron Silver, the Col. Sellers, and the A-Y and Minnie, the combined shipments of which are about 20,000 tons per month.

At Aspen, the Smuggler is the great producer. During 1912, the entire plant was remodelled, electricity being substituted for steam power both for hoisting and pumping. As the ore from this property is probably of the lowest grade mined in the state, any possible reduction in operating cost is important. The Federal Bureau of Mines has undertaken to extinguish the fire which has been smouldering in this mine for several years.

The output of crude ore at Creede in 1912 was 81,829 tons, an increase of 25 per cent. over 1911. The average value of the ore of this district is $13 per ton, made up in the following proportions: Lead, 36.5 per cent.; gold, 21 per cent.; silver, 34 per cent.; zinc, 8 per cent; copper 0.5 per cent. Of the total shipments from Creede in 1912 (40,915 tons) one-third consisted of concentrates. For a description of the ore deposits of Creede, see *Bull.* 530, *U. S. Geol. Surv.*, by Emmons and Larsen.

LEAD PRODUCTION OF COLORADO.(*a*)
(In tons of 2000 lb.)

| County. | 1904. | 1905. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|---|---|
| Clear Creek.. | 1,981 | 1,631 | 1,439 | 1,832 | 1,205 | 1,495 | 1,228 | 1,956 | 2,423 |
| Hinsdale..... | 521 | 446 | 442 | 470 | 82 | 50 | 124 | 60 | 611 |
| Lake..... | 23,590 | 26,424 | 23,918 | 17,032 | 7,169 | 7,061 | 6,364 | 8,119 | 12,368 |
| Mineral..... | 6,673 | 5,940 | 7,443 | 6,490 | 4,119 | 4,526 | 4,066 | 3,501 | 2,634 |
| Ouray..... | 1,022 | 2,674 | 2,861 | 1,803 | 1,516 | 1,354 | 2,021 | 2,002 | 1,531 |
| Pitkin..... | 9,441 | 10,987 | 8,781 | 6,957 | 3,713 | 6,315 | 6,704 | 5,090 | 4,195 |
| San Juan.... | 4,644 | 3,223 | 2,070 | 6,213 | 5,133 | 4,921 | 5,444 | 3,140 | 4,452 |
| Others..... | 5,901 | 6,531 | 6,038 | 5,696 | 5,918 | 6,638 | 3,332 | 8,891 | 8,475 |
| Total..... | 53,773 | 57,856 | 52,992 | 46,493 | 28,855 | 32,360 | 35,283 | 32,759 | 36,689 |

(*a*) As reported by the State Commissioner of Mines.

*Idaho.*—The total lead contents of ore and bullion shipped out of the State in 1912, as reported by the State Mine Inspector, amounted to 148,027 tons, as compared with 137,246 tons in 1911. Shoshone County, embracing the famous localities of Wardner-Kellogg, Mullan, and Burke, accounted for 136,674 tons, or 92 per cent. of the total. In spite of the prevailing opinion of economic geologists that all the probable deposits of the district have been exposed, and that their exhaustion is merely a matter of years, the past two years have seen the development of prosperous mines in newly discovered deposits, and the future of the district is now thought to be as bright as it ever was. New developments of eommercial importance were made in 1912 in every operating section, and in others heretofore discredited. Two old producers, the Last Chance, at Wardner, and the Standard Mammoth, at Mace, both belonging to the Federal Company, are nearly exhausted, the former by loss of its extralateral rights through litigation, and the latter by the pitching of its shoots beyond the end lines of the claim, into the Cleveland-Green Hill property. The latter has now been bought by the Federal Company and will be worked through the openings of the Mace mines. Late in 1912, the Federal Company bought the property of the Star Company, on the Morning vein, immediately west of its own land, and early in 1913 extended its holdings in the same direction by the purchase of the Frisco mine, with its 500-ton mill.

The report of the Federal Mining & Smelting Co., for the fiscal year ended Aug. 31, 1912, shows an operating profit of $858,266, and miscellaneous earnings of $108,676. From these are to be deducted construction and betterments of $98,106, and miscellaneous non-operating expenses of $71,512 leaving a net balance of $797,323, as compared with $1,009,-751 for the previous year.

Mining at all the properties yielded 836,947 (wet) tons of ore, of which 46,087 were fiirst-class; 762,550 (dry) tons were milled. The large increase in first-class ore shipped was due to the doubling of the amount of low-grade first-class sorted at the Morning mine, and to the sorting-plant operations at Wardner.

Production during the year included 118,734 tons of lead concentrates and shipping ore, averaging 42.9 per cent. lead and 20.8 oz. of silver per ton, and 2532 tons of zinc concentrates, averaging 46.93 per cent. zinc. Of this total, 40,087 tons were first-class, or shipping ore, which carried from 22.2 to 52.2 per cent. lead and averaged 33.7 per cent. The first-class shipped from Wardner averaged 44.9 per cent., from Mace 40.6 per cent. lead, and from the Morning 27.7 per cent. lead. From the Omaha lease, 1869 tons were shipped, averaging 26.6 per cent. lead and 47.7 oz. in silver per ton, not included in the above 46,087 tons first-class

from the Federal operations proper. The Omaha lease ore also contained 27,233 lb. copper.

Development work amounted to 18,947 ft of drifting, raising, sinking and cross-cutting. Among interesting changes in the mills may be mentioned substituting Deister slime tables for direct-feed vanners, 8-ft. Hardinge ball mills for grinding, as well as a 7×12-ft. P. & M. tube-mill and 128 more Macquisten tubes at the Morning mill.

The above report has been severely criticized, in connection with a suit brought by a committee of the minority stockholders of the mining company to set aside the contract with the smelting company, as follows:

Assuming the figures in the report are correct and that production has been maintained at last year's average of approximately 10,000 tons of ore and concentrates per month, containing an average, as last year, of 42 per cent. lead, it is evident that about 22,680 tons of lead have been produced in six months after allowing usual deduction of 10 per cent. for "smelting loss." The average price of lead from September 1, 1912 to February 28, 1913, was $4.614 per cwt., or 23 cents higher than the average quoted in the company's last annual report.

This does not agree with the statement in the Secretary's report that "earnings were made in spite of the prevailing low price of lead." The report also fails to mention that the average price of silver for the same period was 62.881 cents. per ounce, as compared with 58 cents recorded in the last annual report. This would account for added earnings of approximately 95 cents per ton of ore, or roughly $9500 per month.

But, instead of receiving the price for lead above quoted, the Federal company, under provisions of its smelting contract, received only $3.94 or 67 cents per cwt. less than the average price of lead, or no less than $5.06 per ton of ore and concentrates shipped. This means that on 60,000 tons produced in six months, the controlling trust has paid for the product shipped it by the Federal company over $300,000 less than its market value, in addition to taking a smelting charge of $8 per ton amounting to $480,000. Other producers in the vicinity of the Federal company enjoy a freight rate to smelting points as low as $6 a ton, but Federal is, by the terms of the contract, to pay a freight rate of $7.15 for the privilege of doing business with the Guggenheims, although the greater portion of the product is shipped to a point where the freight rate is $2.75 per ton.

A dispatch from Washington under date of Apr. 15, 1913, says that complaint to the Department of Justice by Sidney Norman, that the Federal Mining & Smelting Co. is being dealt with unfairly by the American Smelting & Refining Co. will be investigated by the Government in connection with the pending general inquiry to determine whether the

American Smelting & Refining Co. is violating the Sherman anti-trust law. The government will conduct a wide inquiry into the smelting situation, which will require several months to conclude.

The Bunker Hill & Sullivan mine, at Kellogg, operated continuously through 1912, yielding 40,000 tons of ore per month at a net profit for dividends of $1.62 per ton of ore mined. The new concentrating mill was in steady operation while the old mill was being remodeled. During the 19 months ending Dec. 31, 1912, the company mined 702,520 tons and concentrated 697,560 tons. Operating costs were: Stoping, $1.602; tramming, $0.074; concentrating, $0.374; shipping, $0.034; office and superintendence, $0.073; contingent expense, $0.086; legal services, $0.007; total, $2.25 per ton.

The Snowstorm mine, at Larsen, completed the reconstruction of its mill, of 225-ton capacity, and the process is now thought to be as sucessful as is possible in view of the difficult nature of the ore. The year's output was slightly curtailed, for this reason, but underground development was pushed, with encouraging results.

In Lemhi County, the lead-silver mines of the Gilmore district maintained steady production during 1912. The leading operators were the Pittsburg-Idaho, the Latest Out, and the New Gilmore. The latter is a new organization in control of parts of the old Allie properties, adjoining the Pittsburg-Idaho on the east. During 1912 these two companies combined in the driving of a working tunnel from a point reached by railroad spur, whereby the item of wagon haul will be eliminated.

In Blaine County, the most productive mine is the Wilbert, in the Dome district. A 100-ton concentrator was completed and put into operation in 1912. Concentrates have to be hauled 40 miles to Arco. In Custer County, the Clayton mines were bought by the Utah Mining and Smelting Co., and a 100-ton smelter was blown in; the bullion is hauled 60 miles to Mackay.

*Illinois.*—Galena concentrates amounting to 797 tons, carrying 74.6 per cent. lead and 6.31 oz. silver per ton, were produced in 1912 by the Fairview Fluorspar and Lead Co., and the Rosiclare Lead and Fluorspar Co., in southern Illinois. The Galena district, in northwestern Illinois, where the Ten Strike Consolidated is the largest lead operator, produced 864 tons of galena concentrates, carrying 79.5 per cent. lead. Figured on the basis of metallic lead, this production is equivalent to 1282 tons in 1912 as compared with 964 tons in 1911.

*Kansas.*—The output of lead concentrates in 1912 was 3036 tons, containing 2371 tons of lead. Production from the Galena and the Badger-Peacock districts was much curtailed, while that of the Lawton district was doubled, as compared with 1911.

*Missouri.*—The output of lead in 1912 was 168,719 tons, a decrease of 12 per cent. as compared with 181,001 tons in 1911. Southeast Missouri furnished 146,038 tons and the Joplin district supplied 22,681 tons.

The Joplin district produced 37,674 tons of galena concentrates, and 361 tons of carbonate ores. From the sheet-ground mines came about 5,465,100 tons of ore, yielding two-thirds of the entire output of galena concentrates. The other third was obtained from about 3,856,045 tons of ore from the soft-ground mines; all the carbonate ores also came from the soft-ground mines. The recovery of sphalerite concentrates from these same ores will be mentioned under zinc, on a later page of this volume.

PRICE OF CONCENTRATED LEAD ORE AT JOPLIN.
(Per ton of 2000 lb.)

| Year. | 1903. | 1904. | 1905. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|---|---|---|
| Highest..... | $60.50 | $62.00 | $80.00 | $87.00 | $88.50 | $66.00 | $60.50 | $58.00 | $64.00 | $68.00 |
| Average..... | 54.12 | 54.80 | 62.12 | 77.78 | 68.90 | 55.75 | 54.58 | 51.98 | 56.76 | 56.60 |

[1] See under "Zinc," for table showing Joplin lead production, by districts.

PRODUCTION OF CONCENTRATED LEAD ORE IN THE JOPLIN DISTRICT.
(Tons of 2000 lb.)

| Year. | Tons. | Year. | Tons. | Year. | Tons. | Year. | Tons. | Year. | Tons. |
|---|---|---|---|---|---|---|---|---|---|
| 1896..... | 27,721 | 1900.. | 29,132 | 1904.. | 34,362 | 1908.. | 38,533 | 1912.... | 38,035 |
| 1897..... | 30,105 | 1901.. | 35,177 | 1905.. | 31,679 | 1909.. | 43,659 | ..... | ..... |
| 1898..... | 26,687 | 1902.. | 31,625 | 1906.. | 39,189 | 1910.. | 44,037 | ..... | ..... |
| 1899..... | 23,888 | 1903.. | 28,656 | 1907.. | 42,065 | 1911.. | 45,500 | ..... | ..... |

Southeastern Missouri (By H. A. Wheeler).—Little prospecting was done in 1912 by the local companies, and none by outside interests. The agitation about polluting streams with the mill slimes subsided, as the community promptly rallied to the defense of the mine operators when it was recognized that it meant killing the goose that was laying the golden eggs. Boston capital has at last taken an active interest in this disseminated lead belt and will soon have a promising producer.

The St. Joseph Lead Co. produced the largest output in its history, which was derived from five mines of Bonne Terre and Leadwood; the Crawley and Gumbo mines were not operated. The original or No. 1 mine, at Bonne Terre, which exceeds 1 1/2 miles in length, was recently connected by a 7×12-ft. drift with No. 7 mine, about 3/4 mile distant. This will enable the output of No. 7 mine to be brought to the mill shaft by the underground haulage system and avoid taking it over a high hill by a switchback. The No. 1 mill, at Bonne Terre, which is about 30 years

old and has a capacity of 1500 tons per day, is being remodeled to increase its output. The Bonne Terre and Leadwood power plant will be increased by 1250- and 1000-kw. turbo-generators, respectively.

The smeltery at Herculaneum, which has four large rectangular water-jacket stacks for ore smelting and two round water-jacket furnaces for matte smelting, has been equipped with a baghouse to handle the fumes from the four Dwight-Lloyd sintering roasters.

The Doe Run Lead Co., closely affiliated with the St. Joseph Company, broke the high production record of 1911. The ore was produced from five mines and was mainly milled at the new or No. 3 mill, at River mines. The old or No. 1 mill, at Doe Run, built 25 years ago, was finally abandoned. The new mill has a capacity of 2500 tons per day, which is being increased to 4000 tons by adding two more sections.

The Desloge Lead Co. pursued its policy of quietly pushing lead production, and no important construction work was attempted in 1912. Its 1500-ton mill was supplied by three mines, but most of the concentrates were shipped, as it operated only its four small Flintshire furnaces.

The St. Louis Smelting & Refining Co., a branch of the National Lead Co., operated its plant in the Flat River district. The ore was supplied by four mines, the No. 5 mine not being operated. The mill has been remodeled and its capacity increased to 2000 tons per day. The Huntington mills have been replaced by rolls for regrinding the middlings and the Frue vanners have been superseded by additional Overstrom tables, for which the feed is graded into four classes.

The Federal Lead Co., although the youngest of the active producers in the district, maintained the prestige of being the largest individual producer, and its output again made a new record. This is largely due to its leasing and operating the old Catherine mine, in Madison County. The 4000-ton mill at Flat River, the largest in the district, was steadily operated on ore from seven mines in the immediate vicinity. The daily mill capacity was increased by 800 tons in 1912 by adding three more Hancock jigs, while two large jaw crushers and coarse rolls were replaced by two Symons gyratory crushers and four Symons disk crushers. A small magnetic separating plant was added to recover clean zinc and copper concentrates, as by-products, from the lead middlings.

The new Boston company operating on the Jake Day tract on Big River is the St. Francois Lead Co. A shaft was sunk 430 ft. on the river bluff and a spur is now being built to it, from the Leadwood branch of the M. R. & B. T. R. R. The ore will be shipped to the National mill, where sampling arrangements are being provided to take care of it. Ore shipments will probably begin early in 1913.

The famous Mine La Motte property, in Madison County, contrib-

uted its usual quota of lead in 1912, in spite of having been a producer for over two centuries. Its modern production is derived from the deeper disseminated deposits that are found underlying or adjacent to the shallow diggings. This mine now produces 2500 to 3000 tons per year. The smeltery has not been operated for several years, and the concentrates, assaying 65 to 68 per cent. lead, are shipped to the Pittsburg district.

The Catherine mine, opened in 1897, was leased by the Federal Lead Co., the mill was overhauled and remodeled and the mine is again an active producer, the concentrates being shipped to the Alton, Ill., smeltery. The property of the North American Lead Co., at Fredericktown, is still in the hands of a watchman.

*Nevada.*—Nevada produced nearly six times as much lead in 1912 as in 1911, surpassing any production in the last ten years. The increase is due principally to adjustments of litigation and to the completion of the railroad spurs to Bullionville and at Pioche, Lincoln County, in 1912. Regular shipments of lead ore were made through the latter half of the year. Clark County also has a large lead output. The Yellow Pine mill operated the entire year, producing lead as well as zinc concentrates.

*New Mexico.*—The leading producer of lead ore is the Tri-Bullion company, operating at Kelly and at Grand Tower. Its ores are mixed lead-zinc sulphides. The new mill of the Ozark (Sherwin-Williams) company, treating the lead-zinc-copper ore of the Graphite mine, went into operation early in 1913. This is the largest concentrator in New Mexico, and is driven by electricity generated by oil engine.

*Oklahoma* (By L. C. Snider).—The productive lead and zinc field of Oklahoma is in the extreme northeast corner of the State and is a part of the Joplin, Mo., district, the nature of the ores and the mining conditions being the same. There are three mining camps in the field, Peoria, Quapaw and Miami. The last is by far the most important. In 1911 a deeper run of ore was discovered at Miami, which is much richer than the upper run. The exceedingly strong head of water, however, prevented a large production being made. The low price of zinc concentrates also limited the output during the first half of that year.

In 1912, prospecting greatly increased the area known to be underlain by the ore-bodies and extended it almost to the Kansas line. Prices were better than during 1911; the developed leases were worked intensively. A 12-in. steam pump of a capacity of 3000 gal. per minute was installed at the 270-ft. level, which lowered the water level sufficiently to permit working the lower runs. Several new concentrating plants were built or are in course of erection.

The Peoria and Quapaw camps made no marked development in 1912, but will probably show an increased production due to the higher prices for concentrates.

The value of the production of lead and zinc concentrates since 1908 is as follows: 1908, $596,383; 1909, $802,032; 1910, $641,278, and 1911 $513,516. The output for 1912 was greater than that of any previous year, with an approximate value of $800,000. According to returns of the U. S. Geol. Surv., the output of lead concentrates in 1912 was 4257 tons, worth $231,678, all from the Miami district.

*Utah.*—The main output came from Park City, Bingham, and Tintic. The inauguration of lead smelting at Tooele has been referred to on an earlier page.

The Daly West Mining Co., Park City, since its organization, November, 1893, to the end of 1912, has received $15,058,185 for its product, out of which it has paid $6,579,000, or about 44 per cent. in dividends. In 1912, 55,850 tons of ore were mined at a cost of $6.05 per ton, including exploration and development, which amounted to 7131 ft., at an average cost of about $17.60 per ft. General expenses, not included in above, were 54.7 cents per ton mined. Of the 44,260 tons of ore sent to the mill, 1369 tons or 3.1 per cent was sorted out at a cost of $1168, which gives a cost of 85 cents per ton of rock discarded or 2.66 cents per ton of rock handled by sorters. Based upon the tons of sorted ore milled the cost of milling was $1.45 per ton, including assaying charges, but not sorting. The ore milled contained 5.5 per cent. lead, 8 oz. silver, 5.2 per cent. zinc, 3.9 per cent. iron, and 70.4 per cent. silica. The actual saving effected by the mill was 98.7 per cent. of the lead and 81.1 per cent. of the silver. Zinc concentrates made amounted to 1465 tons, assaying 20.62 oz. silver, 6.22 per cent. lead and 34.29 per cent. zinc. The lead concentrates ran 34.45 oz. silver, 0.0358 oz. gold, 30.84 per cent. lead and 1.1 per cent. copper.

The Daly-Judge Mining Co., of Park City, during 1912, produced 62,606 tons of ore, the net value of which was $728,381. The surplus at the end of the year was $524,570 after the payment of $225,000 in dividends.

Total development work amounted to 9784 ft., of which 4002 ft. were driven during the last three months of the year. Since Sept. 1, 1912, systematic exploration has been done under the contract system; it is stated that approximately double the footage is driven in a given time with no greater cost per foot than previously.

The mill treated 58,951 tons of ore from which 13,419 tons of lead concentrates and 4300 tons of zinc middlings were made. The ratio of con-

centration was 4.4 tons of crude ore into one of lead concentrates, or with all products combined, 3.4 tons into one.

In 1912, one Wilfley table, one multi-deck Wilfley slimer, two Callow tanks, one Richards-Janney classifier and one new jig were added to the mill equipment, which resulted in a closer saving and a better separation of lead from zinc.

The average value of the various products per ton for the year is given as follows: 3655 tons of crude ore, sold for $30.23 per ton, assaying 34.83 oz. silver; 0.045 oz. gold, 19.72 per cent. lead, 1.75 per cent. copper, 19.89 per cent. zinc, 11.28 per cent. iron; 13,419 tons of concentrates, sold at $35.09 per ton, the analysis being 32.27 oz. silver, 0.031 oz. gold, 29.71 per cent. lead, 1.60 per cent. copper, 15.30 per cent. zinc, 14.50 per cent. iron; 5425 tons of zinc middlings sold at $27.29 per ton, averaging 22.58 oz. silver, 0.019 oz. gold, 5.16 per cent. lead, 40.46 per cent. zinc and 8.17 per cent. iron.

In the Tintic district, the May Day mine developed important reserves of lead-zinc ore and began regular shipments late in 1912. In December, it shipped six cars of lead ore, valued at $5400, and in January, 1913, followed with nine cars of lead ore. About two-thirds the whole output of this mine is zinc ore, but the lead ore accounts for about half the proceeds.

The Bingham Mines Co. produced in 1912 3,770,320 lb. of lead, 1,427,780 lb. of copper and 225,763 oz. of silver and 3,731 oz. of gold. The average net earnings were $12,000 per month.

*Virginia.*—The lead-zinc mines of Wythe County in 1912 produced 235 tons of lead, a slight decrease from 1911.

*Wisconsin.*—The output of lead ore concentrates in 1912 was 3373 tons (containing 2581 tons of lead) as against 4359 tons of concentrates (3353 tons lead) in 1911. The 1912 output was derived from 1,363,636 tons of crude ore assaying 2.9 per cent. zinc and 0.2 per cent. lead. The lead ore concentrates sold for $53.57 per ton. Benton and Cuba City were the leading producers.

## Lead Mining in Foreign Countries.

*Australia.*—The lead statistics of Australia are hard to interpret, partly owing to obscurity in the official reports, but principally because the ores mined in one state are largely smelted in another state, the base bullion then being exported (along with large tonnages of concentrated ores) to Europe for refining. The majority of the output comes from the mixed lead-zinc ores of Broken Hill; hence a statement of tonnage mined has little significance. Total exports from the Commonwealth

of Australia, during 1912, are officially reported as follows: Argentiferous lead ore, 326,116 cwt.—£214,304; pig lead, 1,438,681 cwt.—£1,262,034; lead contents of matte, 502,264 cwt.—£355,921; lead contents of concentrated silver-lead ore, 2,069,151 cwt.—£1,074,153; manufactures of lead, 17,916 cwt.—£18,812.

New South Wales.—Ore hoisted in the Broken Hill district in 1912 included 28,057 long tons of oxidized, and 1,611,602 tons of sulphide ore; total 1,639,659 tons as compared with 1,484,397 tons in 1911. The output of 1912 was only 13,232 tons less than that of 1907, when the maximum was reached; the tonnage would probably have been the largest on record but for a scarcity of skilled labor. Development work was pushed vigorously, resulting in greatly increased reserves. The gross value of the products of the Broken Hill field in 1912 was £4,436,759, of which £1,256,100 was distributed as dividends. For detailed information re-

EXPORTS OF LEAD FROM NEW SOUTH WALES. (a)
(In tons of 2240 lb.)

| Year. | Pig Lead. (b) | | Silver-lead Ore and Concentrates. | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| 1910 | 21,195 | £248,561 | 317,697 | £1,685,704 |
| 1911 | 17,276 | 209,784 | 338,469 | 2,265,669 |
| 1912 | 17,251 | 264,530 | 345,307 | 3,229,614 |

(a) According to the official statistics of New South Wales. (b) Smelted in New South Wales.

SILVER-LEAD PRODUCTION OF NEW SOUTH WALES.

| Year. | In Bullion. (a) | | In Concentrates Exported. | |
|---|---|---|---|---|
| | Silver. | Lead. | Silver. | Lead. |
| | Oz. | Tons. | Oz. | Tons. |
| 1909 | 3,717,016 | 64,821 | 6,867,775 | 90,307 |
| 1910 | 5,916,323 | 94,818 | 7,608,336 | 85,035 |
| 1911 | 5,731,468 | 94,966 | 8,797,677 | 111,795 |
| 1912 | 5,220,538 | 101,811 | 8,293,711 | 97,736 |

(a) Smelted within the Commonwealth of Australia.

garding the several mines, see the Annual Reports of the Department of Mines of New South Wales.

The Yerranderie district produced 7055 long tons of ore containing 1438 oz. gold, 676,095 oz. silver, and 1906 tons of lead. This district is still retarded by lack of transport; a proposed railway has been surveyed to a point 8 miles from the camp. Only the richest silver-bearing ores are now handled.

Queensland.—In 1912 the Chillagoe mines furnished 1956.5 tons

of lead, and the Silver Spur only 35.5 tons. Other lead was produced from ores in the Etheridge district; 229 tons in 1911 and 204.5 tons in 1912, and the Herberton district, 124 tons in 1911 and 689 tons in 1912, these being treated off the field. Lead as a by-product from other ores also came from the Charters Towers District, which reported 393 tons in 1911 and 189 tons in 1912. The total amount of lead produced in 1912 in Queensland, was 3108 tons, valued at £55,667, including the lead content of exported ore.

In the Chillagoe district in 1912, the Mungana Mines, the Girofla and Lady Jane, continued to furnish lead and copper ores, and development work was pushed. The ore-body at the Eclipse Mine, worked by the Chillagoe company, was 80 ft. by 5 ft. wide, and contained 13 per cent. lead, 8 oz. of silver and 2 per cent. copper. One furnace at the Chillagoe works was smelting lead ores as in 1911. At the Silver Spur the year was devoted to development, and the smelter was not worked. In the Etheridge district, the International Mines is developing bodies of mixed ores at Mt. Jackson.

*Belgium.*—There are nine lead smelters in Belgium, the raw materials for which come from Australia, Algeria and Tunis, and Spain and Portugal, in the order named, together with some from Sweden, England, and Germany. It is reported that a selling company was formed in 1912 to hold exclusive control of the output of these smelters; the immediate result of this move was to stimulate purchases of lead from Germany.

*Burma.*—According to Consul Moorhead, at Rangoon, the production of lead in pigs and ore during 1911 included: Lead bullion, 13,259 tons —$299,029; galena ore, 189 tons—$3,495; silver-lead ore, 3218 tons—$23,403; lead slag, 31,954 tons—$331,926; silver, 103,850 oz.—$55,308. The principal producer is the Burma Mines Co., operating the Bawdwin mine in the State of Tawngpeng, Northern Shan States, and a smelter at Mandalay, employing 536 persons. In 1912, owing to the failure of an important producer, the output of pig lead suffered a decline, the exports of lead materials to all countries except India having been only $598,645, as against $1,078,678 in 1911.

*Canada.*—The total production of lead in 1912 was 17,882 short tons, valued at $1,597,554, or an average of 4.467 cents per pound, the average wholesale price of pig lead in Montreal for the year. In 1911 the production was 11,892 short tons valued at $827,717. The shipments were practically all from British Columbia mines in 1912, a small shipment being made from Ontario mines, but not paid for. Toward the close of the year the North American smelter at Kingston, Ontario, started operations. In British Columbia the resumption of active operations at the Blue Bell and the activity of the Consolidated Mining and Smelting Co.

and of a number of the more important mining companies were factors in the increase.

The exports of lead in ore, etc., in 1912 are reported as 150 tons, valued at $8193. No pig lead was exported.

The total value of the imports of lead and lead products in 1912 was $1,806,221, including pig lead, bars, sheets, tea lead, etc., valued at $1,202,001; manufactures of lead valued at $200,157; litharge and lead pigments, valued at $404,063. The total value of the imports of lead and lead products in 1911 was $1,049,276, being pig lead, etc., $706,020; manufactures, $108,012, and litharge and lead pigments, $235,244.

The amount of bounty paid during the twelve months ending December 31, 1912, on account of lead production, was $118,425.74 as compared with $219,557.70 in 1911. The bounty on lead authorized in 1903 has now paid out $6,000,000. An extension of 5 years from 1913, when the present bounty expires, has been proposed on condition that it will apply only when the London price is below £17 8s. 9d. per ton.

*France.*—According to *l'Echo des Mines*, the lead works at Langeac during 1912 treated 6023 tons of ore and residues, recovering therefrom 860 tons soft lead, 194 tons antimonial lead, 2665 kg. silver, and 102 kg. gold. The Brossette vein is reported to have developed 150,000 tons of sulphide and 50,000 tons of carbonate ore, containing 13 per cent. lead and 350 grm. silver.

*Great Britain.*—The most productive lead mines in the United Kingdom are in Durham and Derby, England, Cardigan and Flintshire, Wales, and Dumfries, Scotland. Two English lead mines are described in *Eng. and Min. Journ.*, Aug. 10, and Sept. 7, 1912. The output of concentrated lead ore in 1912 was 23,368 long tons, as compared with 23,910 tons in 1911. The amount of lead recoverable from this ore is estimated at 75 per cent. The ore, in almost all cases, is galena, much of which is argentiferous. The 31 lead works of Great Britain are forced to rely upon imported metal, and, to a smaller extent, on imported ores. The lead situation of Great Britain can be briefly indicated by the following table:

STATISTICS OF LEAD IN GREAT BRITAIN. (*a*)
(In Tons of 2240 lb.)

| Year. | Metal obtainable from Domestic Ores. | Metal Imported. | Metal obtainable from Imported Ores. | All Exports, Including Lead in Ores and Manufactures. | Available for Home Consumption. |
|---|---|---|---|---|---|
| 1908 | 20,999 | 237,508 | 18,787 | 69,994 | 207,300 |
| 1909 | 22,463 | 207,660 | 12,434 | 60,495 | 182,062 |
| 1910 | 21,522 | 218,936 | 14,474 | 67,104 | 187,828 |
| 1911 | 17,990 | 213,707 | 13,807 | 68,029 | 177,475 |
| 1912 | 17,526 | 205,375 | (*e*)12,500 | 58,685 | 176,716 |

(*a*) From official publications. (*e*) Estimated.

Imports of lead ore come mainly from Australia, Peru, Mexico, Germany, France and Rhodesia; and of lead metal from Spain, New South Wales, United States, and Mexico, in the order named. London is the chief receiving port for both ore and metal. The heaviest exports go to Russia, Canada and Germany.

*Greece.*—The annual report of the Laurium Mines Co., for the fiscal year ending early in 1912 states that 30,000 tons of zinc ores, 10,253 of argentiferous lead, and 63,000 of iron and manganese ores, a total of 103,316 tons, were sold, showing a diminution of 24,000 in comparison with 1910. Zinc ores maintained their output, but that of lead was 1070 tons less. The value of the silver in the lead decreased 3 oz. per ton. The fall in the production of manganiferous iron ores was due to higher freights and the disinclination of the smelters to purchase low-grade ores.

The high price of metals during 1911 permitted a gross profit of £82-461, an excess of £17,401 over that obtained in the preceding year. The briquetting plant, started at the commencement of the year, proved successful, and the last of the roasting furnaces went to work in August. It is proposed to put up works for the utilization of arsenical by-products. Toward the end of 1912 it was intended to begin the examination of the third contact deposits in the north of the concession, one of the great geological problems of Laurium.

*Italy.*—The total output of lead ore in 1911 was 38,458 metric tons, compared with 36,540 tons in 1910. The great majority of the output, or 37,988 tons in 1911, came from the Iglesias district, where the Monteponi works make a successful separation of difficult lead-zinc ores. The small remainder of the output is contributed by mines in the district of Milan. The Monteponi smelter, in 1911, produced 3684 tons of lead, containing 2143 kg. of silver from its own and custom ores. The smelter at Pertusola treated 18,800 tons of argentiferous ores from Sardinia, and 5250 tons of non-argentiferous ores from Tunis, producing therefrom 13,000 tons of lead and 10,000 kg. of silver. The total lead output of the country was thus 16,684 metric tons, worth $1,110,160, in 1911.

*Russia.*—The consumption of lead in 1909 was 40,800 tons; in 1910, 51,290 tons; and in 1911, 42,920 tons; this is mostly imported, but some lead is produced in the Caucasus and Trans Baikal, the Kirghis Steppes, Altai, and the Urals.

In the Caucasus, the only lead smeltery, the Alaghir works, obtains ore from the Sadonsky mine, the ore-body of which is quartz, containing 6 to 7 per cent. lead, 0.02 per cent. silver, 0.06 per cent copper, and 0.013 per cent. zinc.

The Trans Baikal mines are in the Nerchinsk district. Of 90 mines, 5 are being worked. They are in limestone formation. The mines in

the Karkaralinsk district (Kirghis Steppes) produce argentiferous ore with 40 to 78 per cent. lead, and 1.21 per cent. copper. The Altai mines are in two groups, south and northeast. The ore carries from 300 to 650 lb. lead per ton, and 2 to 50 oz. of silver.

A large concentrator is being erected in the Nan Tchan valley on Olga Bay, Primorsk province, (Pacific Coast). The ore hitherto shipped to Germany runs 22 per cent. lead, and 18.9 per cent. zinc. The concentrate will now be shipped to Russian ports of the Baltic and Azoff Seas, where smelters will be erected. In 1912 the lead ore produced at this mine was 30,000 tons.

The richest deposits of zinc and lead ore in Siberia and all the Far East are found in the Olgensky mines, near the town of Vladivostock, on the course of the River Tyutyuche, 20 miles from the Gulf of St. Vladimir, with which gulf they are connected by a narrow-gage railway (*Min. Journ.*, Oct. 29, 1912). This ore contains 22.19 per cent. of lead, 18.90 per cent. of zinc, 27.49 per cent. of iron, 28.38 per cent. of sulphur, and 160 grams per ton of silver. There is a similar mine in the Soadnsky property of the Caucasus, in the Vladikaykaz district. The ore there contains 18 per cent. of zinc, 5 per cent. of lead and 110 grams of silver per ton. All the ore produced at the Olgensky mines is shipped in a crude state, by way of the Pacific Ocean, to Germany. At present the government desires to impose a high export duty on this ore, and the German company which owns the property is constructing reduction works near the mines which will be the first on the Pacific. Other similar mines in this district are near a place called Stolboff, in the Gulf of Preobrazhenie, and again in the valley of the River Uan-Chan, about 14 miles from the sea, and also further north of the Gulf of St. Vladimir, near the village of Tazome.

*Spain* (By E. Mackay Heriot).—On account of the present high prices of the metal a growing activity is noticeable in Peninsular leading mining camps, the chief of which is La Carolina, with an output of 10,000 tons of concentrate per month. The government levies an export tax of 10 *pesetas* ($1.93) per ton on all lead ore shipped. For this reason, practically the whole output of the mines is smelted in the country. Yet competition is still possible; lead ore is shipped to Belgium. Total exports in 1912 were 3522 tons, and 3430 tons in 1911.

There are six smelters in the south of Spain; three at Linares, one at Peñaroya and two in the Cartagena district, Peñaroya being by far the largest. These works have formed a ring, and thus obviate unnecessary competition in the buying of ores, the latter being distributed according to agreement.

In 1912, the Peñaroya absorbed the Escombrera-Bleyberg and the Figueroa, and is now one of the leading concerns of Europe.

The value of Linares ore (75 per cent. Pb and about 180 grm. Ag per ton) with lead at £19 may be taken as being 308 *pesetas*. (1 *peseta* = 19.3 c.) In ordinary circumstances the working cost in the chief mining centers is about 100 to 115 *pesetas* per ton of concentrate, which leaves a good profit. The government duty is 3 per cent. of the ore sold, and every influence is being used to reduce this to 2 per cent. In both the Linares and La Carolina districts no large outlay for concentrating plant is necessary, because hand dressing is about half as costly as mechanical dressing. The ores are exceedingly clean, wages are low and the men are expert at their work. A miner in the south of Spain gets 3.50 *pesetas* per day, a surface worker 2.50, and a dresser from 2 to 3.50 *pesetas*.

Many Spanish lead mines are worked on the "*saca genero*" principle. A certain portion of a mine is given to a tributer at, say, 20 to 28 per cent. Although this system is ruinous for many properties, even large companies have employed it. Taken on the whole, Spanish lead mines have not been worked economically. One reason for this has been that a large number of the companies have been formed locally with insufficient funds. If we except French, there is little foreign capital in this industry. While the British shareholders prefer to look for tin and gold in the furthermost parts of the earth, the French are taking advantage of the promising outlook in these district nesarer home.

Spain has riches in lead and zinc as yet untouched for want of communication, and La Carolina district, although covered with claims by people of small capital, has in spite of its great output few mines at work, although there are plenty of good-looking prospects.

As regards lead-ore outcrops in Spain, in some districts one encounters rich ores at surface, which do not continue in depth, whereas in others it is just the contrary. In La Carolina rich lodes have been discovered by sinking on "cross" lodes containing ore. In some of the great lodes of La Carolina the profitable ore-body does not begin before 50- to 100-m. depth, whereas in Linares the ore in most lodes can be worked profitably near surface.

The number of mines producing lead ore in Spain in 1911 was 137, having an area of 4670 hectares, and employing 13,706 men. The production was 165,843 tons, valued at 27,620,683 *pesetas* at the mine.

## Notes on the Preparation of White-lead Paints.[1]

If, in the examination of dry white lead, it is found to be gritty on rubbing in oil, this may be due to overdrying on steam pans, or to its not having been thoroughly washed free from lead acetate. Such white lead

[1] Abstract from an article on "Paint Making and Color Grinding," *Oil, Paint and Drug. Rep.*, Feb. 24, 1913.

lacks body. The grit may also be due to uncorroded lead, called "blue," which will show on a white slab. For paint purposes, white lead should also be free from litharge, which will give it a yellow cast. The presence of copper and iron in white lead is also objectionable; these can be detected by the discoloration produced with turpentine, greenish in the former, and rusty in the latter case.

Lead acetate, which is objectionable in large quantities, may be tested for by treating with hot water and adding a little sulphuric acid to the clear liquid. When carbonate is in excess over hydrate, the paint has a lack of spreading power, and with the reverse it will lack body on account of too great an absorption of oil. The limits thought to give the best results are between 75 and 78 per cent. of lead carbonate; this refers to quick-process white lead, and not to precipitation or electrolytic.

A modern process, which differs from the old Dutch process, consists in melting the pig-lead and blowing it into fine particles by jets of high-pressure superheated steam. The powder thus obtained is placed in large, wooden, revolving cylinders into which acetic acid is introduced, and the mass is sprayed with water. The barrel contains an atmosphere of carbonic acid supplied from a coke furnace. The average time of corrosion by this process is 12 days, as against 60 days by the stack method and the efficiency is higher. It is true, however, that, in general, white lead corroded by this method, no matter how uniform, is deficient in density, and the material requires a larger percentage of oil for grinding into paste, sometimes 25 to 50 per cent. more. These brands of white lead lack "tooth" or "life," and the argument of large spreading capacity will not appeal to the painter, as the labor counts for more than the cost of material.

The method of grinding white lead in linseed oil is to mix the material, as it comes from drying pans or ovens, in mixers, thence to large-diameter stone mills, and when fine into coolers. Another method, the pulp-grinding process, agitates the undried lead until the lead and oil sink to the bottom, the clear water being on top. The product is then passed over stone mills to eliminate more water. The question as to which process is superior has not been settled, but some corroders are still using the pulp grind. It is claimed that the pulp-ground lead does not show any chalking tendency within three years. Comparative tests were made on paints containing the same percentages of oil; the acetate in both leads was the same; the moisture in the pulp-ground lead was 0.65 per cent. and that in the dry-ground lead 0.29 per cent.

White lead used for exterior work should be ground with pure raw linseed oil, perfectly free from "foots," and well settled, and ground to the proper consistency. For pure white effects, for inside use, etc., bleached

or refined linseed oil should be used. This makes the lead break up more readily, whereas the raw oil produces a stringy lead. White lead ground in boiled oil is specified only for admixture with red lead for use on iron work, or for mixing with varnishes which prefer raw oil; but the practice has been largely abandoned. White lead should be mixed, ground and stored at a temperature above 50° F., as the lower temperatures cause gritty appearances. Dry white lead mixes best when bone-dry; it can be dried in steam-jacketted pans, and then permitted to cool and absorb the natural moisture of the air, which should not exceed 0.25 per cent. The presence of 0.5 per cent. of moisture will prevent smooth mixing, and cause overheating in the mill. This destroys some of the opacity.

The most practical mixers are of a diameter of about 36 to 40 in. and of a depth not over 30 to 36 in. In order to give ample time to mix the oil and lead in one mixer while another is discharging, it is best to install them in pairs. The favorite mills for white lead grinding have always been 36-in. stone mills, the stones being of the French buhr type. It is believed that the so-called "Esopus stones" do just as good work, and with pigments of soft texture yield a larger output. The speed of a 36-in. mill should not exceed 26 r.p.m. The eye of the hopper which controls the feed should not be smaller than 10 in., although for a long time 5 or 6 in. diameter was thought to be sufficient. A stone mill soon becomes hot when set too close or when tightened up; thus the product may be overheated and the stone possibly ruined. A temperature over 160° F. indicates poor work, and the product lacks covering power. This is why some white lead manufacturers have abandoned the use of twin mills and have substituted chasers and roller mills.

In the latter system the lead and oil, when well condensed in the chaser, pass into a strong mixer, the body of which is over the roller mill. The heavy roller in the bed of the chaser crushes the dry lead, and enough oil is added to form a mass of heavy consistency. In order to overcome any gummy material, the intermediate mixer is used, and at this point more oil is added. This process produces the best stiff lead for flat work, and less oil is required as compared with the stone-mill grinding, for example, 8 to 8.5 per cent. by weight of the whole mixture as compared with 9 to 9.5 per cent.

Following the stone mills, cooling devices are used. The usual cooler is a shallow mixer with a mixer blade running approximately the same speed as the mill. Endless canvas belts, on which the material drops from the mills, have been in favor, but require much supervision to prevent formation of crusts and considerable waste. Cooling with cold water in tanks holding 2 to 3 tons has also been used. The lead in this way can be kept

in bulk under water for weeks or months, avoiding the necessity of keeping it in small containers for shipping. When such a storage tank is filled too rapidly, it has been discovered that the product stiffens and may have to be reground. Another method of storage was practised by some corroders some years ago, that is, storing large quantities of white lead in bulk in steel cylinders with funnel-shaped bottoms. Lead stored in a dry state for months has been found to mix and grind more freely and has a better body. The ageing of lead in oil, however, is claimed to be unnecessary.

In the pulp-grinding process, which is adopted by some to save time and the expense of drying, some of the heat is prevented, excepting such as is formed by friction. The well-washed pulp, containing at least 33 per cent. of pigment, is run into a large wooden tank containing a stirring device, and also steam coils of leaden pipes, to bring the temperature up to 120° F. At this temperature the separation is effected most rapidly. The process is usually conducted by gravity. On the floor below, a weighing box on a stationary scale discharges directly over the agitators. These agitators may be 8 to 10 ft. deep and about 3 ft. in diameter, with strong mixer arms on a heavy shaft resting on a cross-bar 3 ft. from the bottom. The oil is given a downward course, while the agitation goes on. The well-washed pulp is run or pumped in while stirring, the excess of water being drawn off. When sufficiently heated, the amount of dry lead is estimated in the weighing box. It is then run into the agitators, and while the mixer arms are in motion a quantity of oil, calculated from the dry weight obtained, is added in a thin stream. The separation of the water is completed in the stone mills. Sometimes the separation of water is effected in 20 minutes in the mixer; at others it requires an hour. The quickest action results while using refined linseed oil. This oil must be refined by the sulphuric acid process, and be well clarified. Raw linseed oil will not answer, as it requires too much time for the separation of the water and too much water remains with the lead.

*Zinc-lead Paints.*—The white pigment, "zinc-lead," offered to paint makers 25 or 30 years ago, originated in the West; it consisted of 28 per cent. lead sulphate and 72 per cent. zinc oxide, and had a rather coarse texture and yellowish color. Mixed with whiting, gypsum, barytes, or clay, or magnesium silicate (asbestine), it found a ready market temporarily, and had a very low price. The pigment was later improved so as to contain 45 to 48 per cent. lead sulphate, with 52 to 55 per cent. zinc oxide, but in spite of this, it is seldom heard of to-day. Owing to its texture, the former pigment required, to produce a stiff paste, 13.3 per cent. linseed oil and 86.5 per cent. of pigment. The improved pigment,

consisting of nearly equal parts of lead sulphate and zinc oxide, required 88 per cent. pigment and 12 per cent. oil.

The leaded zincs recently put on the market are much bulkier, and are said to consist of two-thirds zinc oxide and one-third lead sulphate, but the selling price is considerably less than the cost of the separately mixed pigments. This product originated in Western Missouri. It mixes and grinds well, in the proportion of 87.5 per cent. pigment, and 12.5 per cent. raw linseed oil. There appears to be no objection to the use of this pigment for appropriate purposes.

When two pigments are mixed with oil, the heating effect appears to be greater than if either pigment is ground by itself. The only remedy to prevent lumps is to keep the material agitated only after it leaves the mill and has cooled. A sure way to prevent lump formation in the combined pigment is to place in a power mixer the proper percentage, by weight, of white lead in oil and zinc oxide in oil, both previously ground to proper fineness, and then discharge directly into the containers.

By long practice it has been determined that white paste paint containing about 66 per cent. lead carbonate, 22 per cent. zinc oxide, and 12 per cent. raw linseed oil is best ground in chaser or roller mills, rather than stone mills. In all these so-called combination whites, whether they contain sublimed lead or lithopone with barytes, whiting, etc., the idea is to avoid the badly settled and caked condition in the bottom of the containers.

The grinding of basic lead sulphate is preferably done in stone mills (buhr stones). When sublimed lead first came on the market it had a coarse texture, and heated considerably in grinding; also, 10 lb. of oil were required to every 90 lb. of pigment. The tendency to harden while being mixed with oil was overcome by using 90 per cent. raw linseed and 10 per cent. cottonseed oil. This coarse sublimed lead was composed of 86 per cent. sulphate of lead and 14 per cent. zinc oxide, but to-day that sold by the Picher Lead Co. is composed of 95 per cent. lead sulphate and 5 per cent. zinc oxide. This material will form a very thick crust on top if ground and kept in bulk. When ground in oil for ready-mixed paints, it is usually mixed with lead carbonate or zinc oxide, barytes, china clay, asbestine, or whiting, and with this mixture it works much better than when ground in the pure state.

## The Lead-poisoning Problem

The U. S. Bureau of Labor in 1912 completed a study of lead poisoning in potteries, tile works and porcelain enameled sanitary ware factories, etc. The investigation covered the conditions in sixty-eight establish-

[illegible] 2100 men and 400 women, and was carried on by [illegible]

[illegible] 1100 men employed in the potteries and tile works in- [illegible] Hamilton found eighty-seven cases of lead poisoning [illegible] or one for every twelve or thirteen employed, and [illegible] women fifty-seven cases, or one for every seven employed. [illegible] men engaged in the porcelain enameling of iron sanitary [illegible] of lead poisoning were found in 1911, or one for every [illegible]

[illegible] of danger involved in the various processes depends partly [illegible] of lead used in the glazes and partly on the use or neglect [illegible] and devices for protecting the workers. In the forty white- [illegible] lead. In the seven potteries making art and utility ware [illegible] the eleven tile factories the glazes contained from 5 to 60 per [illegible] white lead. In the ten porcelain enameled sanitary-ware fac- [illegible] enamels are in use containing from 2 to 25 per cent. of lead.

The precautions which should be observed in establishments using lead glazes are indicated by the nature of the danger. Lead is a slowly cumulative poison which enters the human system chiefly through the digestive tract. The mucous membrane of the respiratory tract may absorb lead, and lead has also been found to penetrate the blood-vessels of the lungs and so to reach the general circulation. The greater part of the lead which is breathed in as dust is swallowed with the saliva, thus reaching the stomach, and this is the most frequent mode of poisoning by lead. Next in importance comes poisoning by lead which is carried into the mouth with food or chewing tobacco which has been handled with lead-covered fingers, or left exposed in a room where there was lead dust, or carried in the pockets of dusty clothes. Absorption of lead through the unbroken skin is probably a negligible amount.

The prevention of lead poisoning in a factory in which lead glazes are used depends upon measures to prevent dust, so that a workman need not breathe in lead, and measures to provide for personal cleanliness so that he will not convey lead into his mouth from his fingers or carry it home on his body or clothes.

Preventive measures of both kinds were conspicuously absent in the factories investigated. Generally speaking, no effort was made to keep down the amount of dust, and no provision was made for carrying it off by exhausts or other mechanical devices. Processes which involve no dust were carried on in the same rooms with dusty ones, exposing workers in the first to a wholly unnecessary danger. The construction of the floors and the methods of cleaning added to the risk. Hot water, an

absolute necessity for removing the lead from the hands before eating, was furnished in but a few instances, and soap and towels not at all. Lunch rooms were not provided, and in many instances workers ate wherever they could find a place, regardless of whether or not lead dust was thick about them. No medical care was given the employees except when one of them was taken violently ill while at work in the factory.

Lead works in Germany produce 44,500,000 marks worth of lead, of which one-third goes to the making of lead colors, chiefly white lead. The earliest attempts at the control of plumbism date from 1876, but the problem has not yet been solved. (*Chem. Zeit.*, 1912, p. 882.) Substitutes for white lead are not successful and the present position is that lead may be used in color-making under certain precautions, some technical and some personal, regulated by the German Act of 1903. The chief technical precaution is the avoidance of dust. Personal precautions include medical examination and the supply of prescribed food and medicines. Alcohol is prohibited in the works. Respirators and special wearing apparel are furnished. As a result of the new act, plumbism has been reduced by 25 per cent. in the Cologne district. The author considers that the most essential problem is the education of the worker to a higher standard of cleanliness.

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## RECENT IMPROVEMENT IN LEAD SMELTING

BY H. O. HOFMAN

### INTRODUCTORY; PHYSICAL PROPERTIES; ALLOYS; COMPOUNDS

*Properties of Lead.*—Books on general chemistry frequently state there exist allotropic modifications of lead. Cohen-Inouye[1] have studied this subject and found that there exist no allotropic forms. The paper contains good illustrations of dendritic crystals of lead obtained in depositing from aqueous solutions. However, according to Loutschinsky,[2] a difference exists between the magnetic permeability of lead that has solidified from the liquid, and solid lead that has been treated mechanically. The rearrangement of the crystal forms on the surface of strained lead can be induced by prolonged etching. This is shown by Baucke.[3]

*Corrosion of Lead.*—According to Mengarini Scala,[4] 100 c.c. distilled water dissolves 0.00121–0.00135 grm. Pb per hour, for the first 10 hours, from 33.04 sq. cm. of surface; solution then dimininishes to, *e.g.*,0.00036 grm. per hour after 240 hours. The presence of electrolytes changes the dissolving power of water (see original).

A piece of lead pipe[5] which had lain in the ground for 24 years, one half imbedded in cement and the other covered by earth, was found, upon sawing in two, to have remained intact in the portion covered by earth, but strongly corroded in the portion imbedded in cement. The corroded part consisted of 24 concentric rings of red lead, $Pb_3O_4$, and 23 of yellow PbO.

Vaubl[6] found that lead-pipe was readily corroded by ordinary lime mortar. He attributes this corrosive effect to the formation of hydrous calcium superoxide when the mortar is setting and hardening, and finds that an emulsion of calcium hydroxide forms a corrective.

[1] *Zt. physik. Chem.*, 1910, LXXIV, 202.
[2] *Rev. Métallurgie*, 1909, VI, 986.
[3] *Internat. Ztschft. Metallographie*, 1912, II, 243.
[4] *Mem. accad. Lincei*, VIII, 576, through Abstracts, *Am. Chem. Soc.*, , 1912.,VI. ,1271.
[5] Kohlmeyer, *Chemiker Zeitung*, 1912, XXXVI, 993.
[6] *Ztschft angewandte Chemie*, 1912, XXV, 2300.

*Soldering of Lead Tubes.*—A history of this art has been prepared by Von Lippmann.[1]

*Lead-Calcium.*—The investigation of Baar[2] of the system Pb–Ca has shown the existence of three chemical compounds $Pb_3Ca$, PbCa, and $PbCa_2$, melting respectively at 650, 960 and 1100° C.; there further exist two eutectics, one with 63 atomic per cent. (=91 wt. per cent.), freezing at 634° C., and the other with 11 atomic per cent. (= about 38 wt. per cent.) freezing at 787° C.

*Lead-Tin.*—The hardness of this series of alloys has been studied by Stenquist[3] with the Brinnell method. The curve drawn has a paraboloid form; the greatest hardness number lies between 50 and 55 per cent. tin.

*Lead-Antimony.*—The determination of the percentage of antimony in hard lead by means of Beckmann's method forms the subject of a study by Friedrich.[4] The method consists in determining the freezing-point of the hard lead to be examined by means of a silica-glass thermometer. From the freezing-point curve of the Pb-Sb series of alloys (lead freezes at 326° C.; the eutectic with 13 per cent. Sb at 228° C.), the first retardations between 0 and 13 per cent. Sb correspond, of course, to definite percentages of antimony. By allowing an alloy within this range to cool from the liquid state to freezing, the percentage of antimony can be read from the retardation shown by the thermometer. Friedrich finds that the thermometric readings show with sufficient accuracy for technical purposes the values of antimony in hard lead containing up to 8 per cent. Sb, and that such an assay takes only 1 minute. Alloys containing over 8 per cent. Sb are diluted with lead to fall within the permissible range.

*Lead-Tin-Antimony.*—A second paper upon this alloy series has been published by Campbell.[5] The first paper was noted last year.[6] The author confirms the transition point of 245° C., which corresponds to 80 per cent. Pb, 10 per cent. Sb, and 10 per cent. Sn; he establishes a second point at 190° C. of the composition 40 per cent. Pb, 2.5 per cent. Sb, and 57.5 per cent. Sn. The second alloy may contain more than 2.5, but not more than 3 per cent. Sb.

*Lead-Tin-Bismuth.*—A further study of his experimental results[7] led Parravano[8] to the conclusion that in this ternary system two of the binary systems form eutectic mixtures throughout, while in the third binary there is formed a compound during cooling.

[1] *Chemiker Ztg.*, 1911, XXXV., 437.
[2] *Ztschft. anorg. Chem.*, 1911, LXX, 372; *Revue Métallurgie, Extraits*, 1912, IX, 441.
[3] *Ztschft. physik. Chemie.*, 1910, LXX, 536.
[4] *Metallurgie*, 1912, IX, 446.
[5] *Metallurgie*, 1912, IX, 422.
[6] MINERAL INDUSTRY, 1911, XX,470.
[7] MINERAL INDUSTRY, 1911, XX, 470.
[8] *Internat. Ztschft. Metallographie*, 1912, II, 15.

*Lead-Tin-Zinc.*—This series of ternary alloys has been studied by Levi-Melvano and Ceccarelli.[1] They found that the ternary eutectic lay at 177° C. and corresponded to an alloy with Pb 24 per cent., Sn 71 per cent., Zn 5 per cent. The hardness of the series was studied by the Brinnell method.

*Lead Sulphide, Antimonious Sulphide.*—The investigations of Wagemann[2] show that there exists an eutectic $Sb_2S_3$–2 PbS. $Sb_2S_3$ with 17 per cent. PbS freezing at 426° C.; that between 44 and 58.8 per cent. PbS and below 577° C. a solid solution of $Pb_2S_3$ in $2PbS.Sb_2S_3$ separates; that 577° C. denotes the formation temperature of the chemical compound $2PbS.Sb_2S_3$; and lastly that PbS forms a solid solution with $2PbS.Sb_2S_3$ up to 4.1 per cent. PbS. In determining the freezing-point of PbS it was noticed that in allowing the liquid sulphide to cool in a current of nitrogen under a cover of charcoal the retardation occurred at 1080° C., while if no charcoal was used, freezing took place at 1109° C. This appears to show that charcoal, even when dried at 120° C., may act as a carrier of oxygen and not as a reducing agent. A small amount of PbO or $PbSO_4$ formed by oxidation, reacting upon PbS and setting free some Pb, causes a lowering of the melting point as shown by Friedrich and Leróux[3] in their investigation of the system Pbs–Pb.

The research of Jaeger[4] leads to results differing from the preceding. In tracing the freezing-point curve PbS–$Sb_2S_3$, he found one hidden chemical compound $2PbS.Sb_2S_3$ at 609° C. corresponding to jamesonite, and a second compound, $5PbS.4Sb_2S_3$, melting at 570° and corresponding to plagionite; also an eutectic of plagionite and stibnite, with 80 per cent. PbS, melting at 495° C.

*Lead Sulphide-Stannous Sulphide.*—W. Heike[5] has studied the freezing phenomena of the series PbS–SnS. He found a solid solution of PbS with 8 per cent. SnS, and a solid solution of SnS with 61.27 per cent. PbS, and showed the probable existence of the chemical compound $PbSnS_2$ which solidifies at 880° C., the freezing-point of SnS. The figure 880° C. agrees with the earlier determination of Biltz and Mecklenburg.[6]

*Lead Chloride—Margnesium (Calcium) Chloride.*—Among the researches of O. Menge[7] upon the systems $MgCl_2$, or $CaCl_2$, with the chlorides of K, Na, Ag, Pb, Cu, Zn, Sn and Cd, those referring to lead interest us here. He finds that the series $MgCl_2$–$PbCl_2$ shows a eutectic with 91 per cent. $PbCl_2$ freezing at 455° C., the melting-point of $MgCl_2$ being 710° C. and that of $PbCl_2$ 496°. In the series $CaCl_2$–$PbCl_2$ also an

[1] *Gazetta chimica italica*, 1911, XLI, 269, through *J. Institute Metals*, 1912, VII, 278.
[2] *Metallurgie*, 1912, IX, 537.
[3] *Metallurgie*, 1905, II, 538.
[4] VIII *Internat. Congress Appl. Chem.*, 1912, II, 139.
[5] *Metallurgie*, 1912, IX, 313.
[6] *Ztschft. anorg. Chemie.*, 1909, LXIV, 227.
[7] *Ztschft. anorg. Chemie*, 1911, LX, 162, *Revue Métallurgie, Extraits*, 1912, IX, 550.

eutectic is formed with 83 per cent. $PbCl_2$ freezing at 467°, the melting-point of $CaCl_2$ being 777°. In both cases the eutectic line extends to the ordinates.

*Red Lead.*—Milbauer[1] tested the formation in O of $Pb_3O_4$ from PbO at temperatures ranging from 325 to 520° C. and at pressures of from 1 to 12 atmospheres. He found that the speed of the reaction $3\ PbO+O \rightarrow Pb_3O_4$ is much accelerated by pressure.

*Lead Sulphate.*—Hofman and Wanjukoff[2] investigated the decomposition of hydrous and anhydrous metallic sulphates when heated in a current of air. They found that $PbSO_4$ showed the first signs of dissociation at 637° C., and that energetic decomposition began at 705° C. with the formation of $6PbO.5SO_3$. This salt undergoes a transformation at 847°, begins to be decomposed at 888°, to sinter at 896°, and to fuse at 910°; rapid dissociation into $2PbO.SO_3$ (?) begins at 952°, and is accompanied by volatilization of PbO; retardations in the heating curve at 958 and 962° indicate an acceleration of decomposition, which, however, is not complete.

*Lead Silicates.*—In two preceding reviews[3] the results of the studies of Hilpert-Nacken and of Cooper-Shaw-Loomis upon the system PbO–$SiO_2$ have been recorded. Cooper-Kraus-Klein[4] have continued the work by an optical in addition to the usual thermal analysis. They conclude that the compounds $PbO.SiO_2$, $2PbO.SiO_2$, and $3PbO.2SiO_2$ are now definitely established. The properties of prepared $PbO.SiO_2$ and $3PbO.2SiO_2$ correspond with those of the minerals alamosite and barysilite.

## Lead Ores

The new smelting schedules of the American Smelting and Refining Co. for Clear Creek, Gilpin and Boulder Counties, Colorado, are published in the *Eng. and Min. Journ.*, 1912, XCIV, 509; the rates prevailing in Utah are given on page 125.

## Smelting Practice

*Sublimed Lead.*—The process of the manufacture of this basic sulphate of lead is described with drawings by E. W. Buskett.[5] Sublimed lead contains from 75 to 90 per cent. $PbSO_4$, and from 25 to 10 per cent. there is usually present from 2 to 5 per cent. ZnO the contents of $ZnSO_4$ ought not to exceed 1 per cent. and that of $CO_2$ 0.07 per cent.; the last

[1] *Chemiker Zeitung*, 1912, XXXVI, 1436, 1484.
[2] *Trans. Am. Inst. Min. Eng.*, 1912, XLIII, 523.
[3] Mineral Industry, 1910, XIX, 438, 1911, XX, 472.
[4] *American Chemical Journal*, 1912, XLVII, 273.
[5] *Min. and Eng. World*, 1912, XXXVI, 393.

has a harmful effect upon the product. Analyses are given in the accompanying table.

ANALYSES OF SUBLIMED LEAD.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $PbSO_4$ | 81.4 | 78.5 | 82.6 | 79.6 | 84.0 | 80.9 | 88.3 | 73.5 | 77.9 |
| PbO | 14.9 | 17.0 | 13.4 | 15.0 | 10.1 | 14.2 | 8.5 | 20.5 | 16.5 |
| $ZnSO_4$ | 1.0 | 1.0 | 1.0 | 2.8 | 2.1 | 0.6 | 0.32 | 1.8 | 2.6 |
| ZnO | 2.3 | 3.4 | 2.9 | 2.5 | 3.5 | 3.8 | 2.2 | 4.1 | 2.8 |
| $SO_3$ | 0.082 | ..... | ..... | ..... | ..... | 0.032 | 0.06 | none | none |
| $CO_2$ | trace | ..... | ..... | ..... | ..... | ..... | ..... | none | none |
| $H_2O$ | 0.2 | ..... | ..... | 0.1 | 0.2 | ..... | ..... | 0.1 | 0.2 |
| Total | 99.882 | 99.9 | 99.8 | 100.0 | 99.9 | 99.532 | 99.38 | 100.0 | 100.0 |

The process of manufacture consists in smelting in the slag-eye furnace sulphide and oxide lead-bearing material with coke and flux. The slag-eye furnace is an oval water-jacket blast furnace, 4 ft. high, 5 by 4 ft. at the throat and 4.5 by 3.5 ft. at the base. At the front it has a tapping-jacket, 18 in. square; 18 in. from the bottom are six 2.5-in. tuyères on a side, 18 in. apart, and two 2.5-in. tuyères at the back, 12 in. apart. The oval jacket rests on a brick base which extends 6 in. upward inside the jacket. The furnace has a hood (combustion chamber) supported by columns; sometimes it is water-cooled; it contains the feed-hole, 1 ft. high and from 2 to 4 ft. wide. The slag runs continuously from the tapping-jacket into a fore-hearth for the separation of lead, and overflowing is granulated by a stream of water impinging upon it. It retains about 2 per cent. Pb. The furnace is worked with a hot top. The dust- and fume-laden gases are drawn by a fan through a tower for cooling the gases and settling the dust, and pass thence through goose-necks to complete these two processes; charged with sublimed lead alone they are forced into the baghouse in which are inverted hoppers, each with 20 bags.

In blowing in a furnace, this is warmed with wood, then filled with coke, and the blast turned on. The first reocharge is given when the coke has become red hot on the surface. Charges are fed frequently, but with little regularity, the feeder working off the total to be smelted in 8 hours to suit his convenience or judgment. A regulated method is one in which the components of each charge are weighed: galena 500, gray slag 450, silica 10, iron cinder 130, limestone 10; total 600; coke 135 lb. The coke is first given, then comes the galena, this is followed by a mixture of gray slag, blue fume (PbO 42.24., PbS 4.63 $PbSO_4$ 47.68, $(FeAl)_2O_3$ 0.52, $SiO_2$ 0.24, $SO_2$ 0.496, ZnO 0.75, C, etc., 3.4), burnt blue fume (ZnO 2.90, S 5.71, Pb 74.90), silica, iron flux (puddle cinder) and limestone ($SiO_2$ 5, CaO 45.9, $Fe_2O_3$ 0.05, $Al_2O_3$ 6.9). The following partial slag analyses are good examples.

| | | | | | |
|---|---|---|---|---|---|
| ...-... | 0.8 | 4.5 | 1.1 | 2.6 | ..... |
| $O_2$... | 28.0 | 26.4 | 27.8 | 26.2 | 32.2 |
| ...O... | 16.8 | 23.2 | 20.4 | 18.6 | 12.5 |
| ...O... | 36.0 | 34.0 | 40.7 | 42.5 | 36.0 |

The cost of smelting per ton of ore with a daily capacity of 40 tons of ...re is $3.36 excluding costs of sales, interest, amortization and repairs.

*Lead Chromate.*—L. S. Hughes[1] proposes a new method for converting ...re-hearth fume into marketable lead chromate. The fume, which con...ains as much as 20 per cent. of the lead in the original ore, is passed ...hrough a settling chamber and filtered in a baghouse. The filtered ...ume when collected in the cellar of the baghouse is ignited and allowed ...o roast. This fume, with about $PbSO_4$ 55 per cent., PbO 44 per cent., ...nO 0.1 per cent., and $Fe_2O_3$ traces, is ground with dry caustic soda, ...he mixture being fed with water into a double-cone continuous ball-...ill having a small feed- and a large discharge-opening. The hydration ...f the caustic soda evolves enough heat to render the solution hot. The ...evolving of the mill prevents any settling of the charge, and a gradual ...ddition of water causes complete solution of the charge without too ...uch dilution. The overflow from the mill is collected in a tank which ...eceives the amount of acetic or nitric acid theoretically necessary to ...orm a basic salt, is diluted with water, and then charged with the ...ecessary quantity of alkali chromate or bichromate. The cost of pro...lucing 100 lb. lead chromate, using burnt fume at 2.5 cents per pound, ...s given as $6.68, while the cost with litharge at 5.5 cents per pound ...would be $8.25. It is suggested that from the alkaline hydrate solu...ion, lead hydroxide may be precipitated, filter-pressed and sold; also, ...hat lead arsenate may be prepared cheaply by adding a solution of $As_2O_3$ in $HNO_3$ and boiling.

*The Pennsylvania Smelting Co., Carnegie, Pa.*—A description of this ...lant is given by S. L. Goodale and H. C. Ray.[2] This plant is the suc...essor of the Pennsylvania Lead Co. which was dismantled after it ...ad been bought by the American Smelting and Refining Co.; it does a ...eneral smelting business, treating silver-lead ores and desilverizing lead ...ullion by the Parkes process. Ordinary smelting is carried on in the ...last furnace, the ore being charged raw, and the iron matte roasted; ...ich silver ores from Cobalt, Ont., are treated in a reverberatory with ...aterial rich in lead in order to extract the bulk of the silver.

There are two blast furnaces, 36 by 108 in. at the tuyères. The coke ...s supplied from a beehive plant having four ovens. The blast furnace ...harge contains from 10 to 20 per cent. Pb, requires from 12 to 15 per ...ent. coke; the composition of the slag aimed at is $SiO_2$, 32 per cent., FeO,

[1] *Jl. Indust. Engin. Chem.*, 1912, IV, 262, *Min. and Eng. World*, 1912, XXXVI, 901.
[2] *Min. and Sci. Press*, 1912, CV, 104.

34 per cent., Ca(Mg)O, 17 per cent., the lead bullion produced assays Ag 80-800 oz. per ton and little or no Au; the slag is poured from the pots into a reverberatory settling furnace, 10 by 6 ft., fired with natural gas; the matte is crushed to 1/4-in. size and roasted in three hand-reverberatory furnaces, 40 by 14 ft.

In the desilverizing plant, the lead-bullion is softened in 12 to 24 hours in a reverberatory furnace with a hearth 9 by 12 ft.; the softened bullion is desilverized in two kettles 7 ft. 7 in. in diam. with three or more zinkings, the stirring being done by means of a steam pipe; rich crust is freed from adhering lead in liquating kettles 3 ft. 10 in. in diam., and distilled in graphite retorts fired with natural gas. A charge of 1000 lb. crust is retorted in about 5 hours. The desilverized lead is freed from zinc in a reverberatory furnace and cast directly through a swinging pipe. The retort bullion is cupelled in an English cupelling furnace; the elliptical test, suspended at the front with the Lynch block and tackle, is lined with cement and ground brick. The fine silver is granulated, smelted in a retort and cast from this into bars weighing about 1100 oz.

The plant makes assay litharge and assay lead, the latter is produced by pouring lead into a cast-iron cylinder with two holes 1/16 in. in diam. in the bottom, atomizing the streamlets with compressed air, and screening to remove the oversize.

*Smelting at Salida, Colorado.*—G. J. Hough[1] furnishes a brief description of the smelting plant of the Ohio and Colorado Smelting and Refining Co. The sampling department has a capacity of 100 tons ore in 10 hours; small shipments are sampled by fractional selection, larger ones by Vezin machines, oxide ores go direct to the blast furnaces, sulphide ores are bedded in order to furnish correct mixtures for Godfrey roasters and Dwight-Lloyd smelting machines. A Godfrey furnace treats per day 30 tons ore mixture and reduces the sulphur contents to 15 per cent.; three of the Dwight-Lloyd machines are 48 in. wide, one is 36 in.; the blast-roasted ore retains 5 per cent. S; a 48-in. machine treats in 24 hours 48 tons of mixture. In the smelting department there are 2 blast-furnaces 45×144 in. at tuyères, and 2 with a tuyère area of 45×180 in. One large and one small blast furnace are served by one main and they smelt about 420 tons of charge in 24 hours with a blast pressure of from 30 to 36 oz. The furnaces are fed by hand; slag and matte are tapped into settlers. The waste slag is hauled by electric traction to the dump, the matte is tapped at intervals from the forehearth, the lead bullion is tapped into small bullion pots, skimmed and ladled into bars.

*Junk Lead.*—The amount of lead annually recovered from scrap and junk is considerable. Liddell[2] estimates that in 1910 the amount of lead

[1] *Min. and Sci. Press*, 1912, CIV, 895.

[2] *Eng. and Min. Journ.*, 1912, XCIII, 452.

recovered as pure lead was 29,384 tons, and in the form of alloy 25,939 tons. Considering that the lead product of the United States in 1910[1] was 488,069 tons, it is seen that the junk lead recovered from scrap was equal to 15 per cent. of the new lead produced from ores; the industry is therefore one of importance.

The furnace commonly used for treating scrap and drosses is the reverberatory. Such a furnace, with air-cooled hearth 4.5 by 7 ft., receives a charge of 3000 lb., is mixed with charcoal and smelted in 6 hours, being rabbled at intervals. Lead and slag are tapped into an overflow-kettle holding about 2300 lb. of metal and 250 lb. of foul slag, while the remaining 250 lb. of clean slag, flow on to a sand bed. Two slags showed the following compositions: Insol, 36.22 per cent., FeO, 32.81 per cent., CaO, 13.12 per cent., S 0.55 per cent.; and $SiO_2$, 41.35 per cent., FeO, 9.24 per cent., CaO, 17.50 per cent., MgO, 3.14 per cent., $Al_2O_3$, 27.05 per cent., Pb, 0.92 per cent., Cu, 0.22 per cent., Sb, trace, Sn, 0.41 per cent. The foul slag goes to the next charge, the lead is transferred to a refining kettle where it cools and is drossed. The dross goes back to the reverberatory furnace. The drossed lead is transferred to three kettles, each of 1.5 tons capacity; here usually tin is added to form solder which goes to market. When a cast of pure lead is to be made for plumber's use the drossed lead is transferred to a 5-ton kettle.

*Refining Impure Lead.*—J. Asbeck[2] patented a process for refining old storage batteries and waste material from lead accumulators. It consists in melting down the material at a temperature of from 400 to 500° C. with alkaline and sulphurizing zinc fluxes; the mixtures recommended are: $3NaOH+1S$, $1NaOH+1Na_2S_2O_3$, and $3NaOH+1NaS$.

*Blast Roasting. Early Pot-roasting.*—The form of apparatus used by Huntington-Heberlein, Savelsberg and others in their blast-roasting processes appear to have been anticipated by Roswag.[3] He used a spherical kettle fired from below, similar to the one used in the Pattinson or Parkes process. He forced air into the charge through a vertical pipe, introduced through the hood which is placed over the kettle to carry off the dust and gases.

In the kettle there was a bath of lead, from 3 to 4 in. deep, into which reached the end of the pipe; from 5 to 6 tons crushed sulphide or matte were charged, the lead brought to a dull red, and the blast turned on. On and off it was found necessary to remove the pipe and cool it. Argentiferous lead-copper matte (*op. cit.*, section 2, Vol. V,) was thus blast-roasted at the Herrerias works, near Villaricos, Spain. Judging by

[1] Mineral Industry, 1911, XIX, 421.
[2] U. S. Patent, No. 1025956, May 14, 1912; *Met. Chem. Eng.*, 1912, X, 433; *Brass World*, 1912, VIII, 195.
[3] Frémy, "Encyclopedie Chimique," Demod, Paris, 1884, section 1, Vol. V, p. 243; *Eng. and Min. Journ.*, 1912, XCII, 750.

the present practice of blast-roasting the reasons for abandoning the process must have been the imperfect desulphurization and the difficulty of removing the cake from the kettle.

C. O. Bannister[1] has published an extended paper on the theory of blast roasting which contains records of experiments upon the roasting of galena concentrate, alone and with various additions, in a gas-fired assay-muffle which give the thermal and chemical changes the charges underwent. The concentrate contained Pb 78.56 per cent., S 11.79 per cent., $SiO_2$ 2.20 per cent., Fe 2.24 per cent., Zn 1.98 per cent. It was

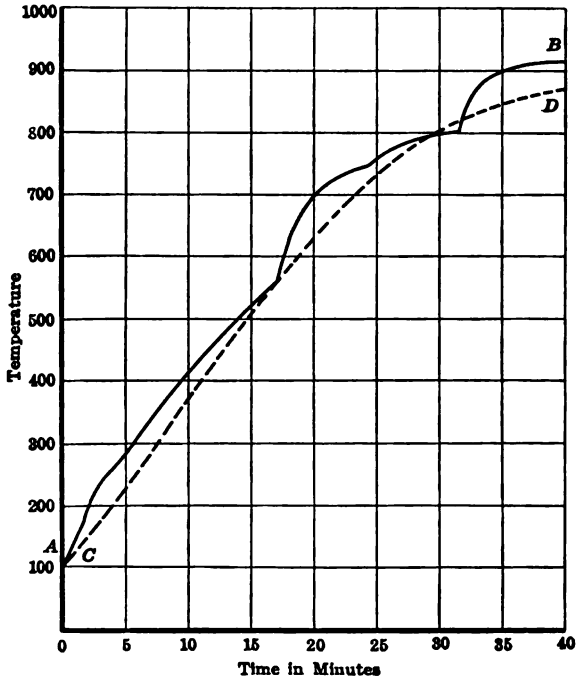


FIG. 1.—Galena-lime Mixture.

mixed with 20 per cent. lime, which gave a mixture of the composition PbS 70.4 per cent., CaO 20.9 per cent., $SiO_2$ 1.7 per cent., not determined 7.0 per cent. The record of the roast is shown in Fig. 1. There is a slight evolution of heat between 180 and 260°, due to the oxidation of a small amount of pyrite; at 560° a considerable rise in temperature takes place accompanied by a glowing of the charge; the evolution of heat diminishes after 730° but is followed by a second rise at 745° which was not sufficient to cause the ore to glow, at 800° a third rise occurs which

[1] *Trans. Institution Mining and Metallurgy*, 1912–12, XXI, 346.

es the charge to glow and the temperature to rise rapidly to 900°. first evolution of heat, now shown to take place at 560°, was noticed Percy and later by Hutchings (MINERAL INDUSTRY 1905., XIV, 403). composition of the charge after the first glow had changed to PbS per cent., $PbSO_4$ 7.3 per cent., PbO 28.7 per cent., CaO 16.0 per ., $CaSO_4$ 10.4 per cent., $SiO_2$ 1.6 per cent., not determined, 7.7 per ., and after the second to PbS nil, $PbSO_4$ nil., PbO 56.0 per cent., CaO per cent., $CaSO_4$ 29.5 per cent., $SiO_2$ 1.5 per cent., not determined per cent.

A second experiment was made with an admixture of 20 per cent. . The original charge had the composition: PbS, 72.6 per cent.,

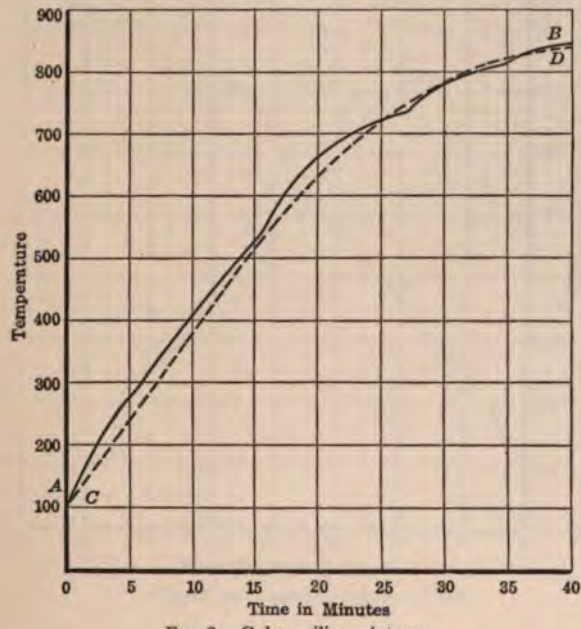


FIG. 2.—Galena-silica mixture.

21.7 per cent., not determined 5.7 per cent. Curve 2 furnishes the rd; the dotted line *CD* represents the blank test, the curve *AB* the rvations with the charge. Between 180 and 290° C. there is again ght evolution of heat due to the pyrite present; the first rise in perature due to the oxidation of galena occurs at 535°, the second at , and the third at 810° C.; the first two evolutions take place at tly lower, the third at slightly higher temperatures than do those d with the lime mixture; all three evolutions are less intense. This s to show that CaO has some other effect with galena besides act-

ing simply as a diluent of the charge. Practical experience with blast roasting has shown that charges with an admixture of lime work better than those having other diluents. The original charge after heating to 700° changed to PbS 30.0 per cent., $PbSO_4$ 26.7 per cent., PbO 17.8 per cent., $SiO_2$ 21.2 per cent., not determined, 4.3 per cent., and after heating to 850° C. to PbS 1.0 per cent., $PbSO_4$ 51.1 per cent., PbO 22.1 per cent., $SiO_2$, 21.0 per cent., not determined, 4.2 per cent.

A third test was made with a galena-litharge mixture. At 550° C the charge glowed as intensely as with the galena-lime mixture, addi-

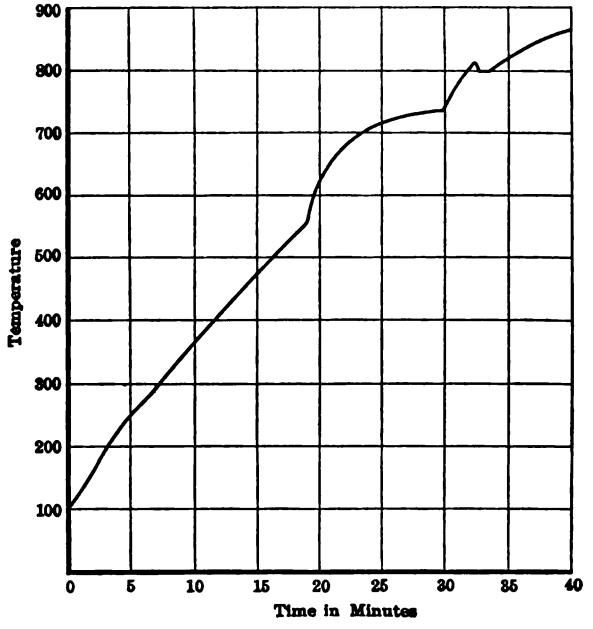


FIG. 3.—Galena-litharge-lime Mixture.

tional glowings were noticed at 720 and 800°. In order to protect the litharge from sulphatization, some lime was added to the mixture when the charge consisted of galena 80 per cent., litharge 5 per cent., and lime 15 per cent. The record of experiment with this charge is given in Fig 3. Neglecting the slight rise in temperature between 160 and 260° C. due to pyrite, the first decided evolution of heat occurs at 560° causing the charge to glow; at 737° a very rapid rise in temperature is noticed, reaching 815°. As the temperature of the muffle is lower than this, the charge cools to 797° when a third exothermic reaction causes a third evolution of heat.

The behavior of the Savelsberg mixture is represented by Fig. 4. The mixture was made up of 80 parts galena and 35.7 parts calcium carbonate (= 20 parts CaO). Passing over again the slight upward bend of the curve between 180 and 290° C, the first evolution of heat takes place at 600° causing the mass to glow. The temperature rises only to 120° as against 170° with lime, the reason being the decomposition of $CaCO_3$ by $SO_3$. At 740° there is a second, and at 805° a third rise in temperature, the last being decided causing the temperature of the charge to be much higher than that of the muffle and falling quickly when the exothermic reaction is at an end.

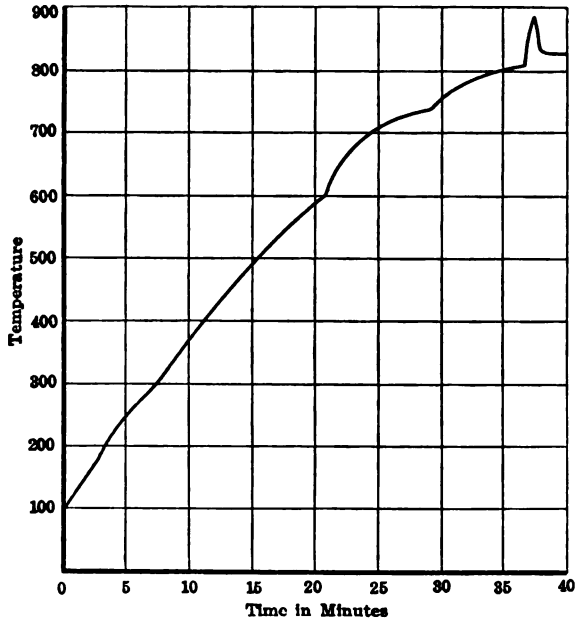


FIG. 4.—GALENA-limestone Mixture.

The behavior of the Carmichael-Bradford mixture, 80 per cent. galena and 20 per cent. dehydrated calcium sulphate is shown in Fig. 5. Evolutions of heat are noticed at 560, 740 and 815° C, but they are mild; the curve resembles in its general features that of the galena-silica mixtures. An entirely different curve would result, if observations were made in regular blast roasting. This is shown by the work of Schütz.[1]

C. O. Bannister has investigated also the behavior of PbS-MgO, $PbS–Fe_2O_3$, $PbS–CaO–H_2O$ mixtures for which curves are given in the original. The paper concludes with a series of experiments carried on

[1] MINERAL INDUSTRY, 1911, XX, 480.

in an electric resistance tube furnace aiming to ascertain the rate of evolution of $SO_2$ with the mixture tested in the muffle.

*Important Factors in Blast Roasting.*—Under this heading, H. B. Pulsifer[1] furnishes a general article with special reference to the Greenawalt intermittent down-draft apparatus. An important bibliography and list of patents accompany the paper.

As to the permissible sulphur-content of the charge, it appears that a charge rich in lead may contain from 9 to 12 per cent. S, and ore low in lead as much as 20 per cent; the reason for this lies in the different

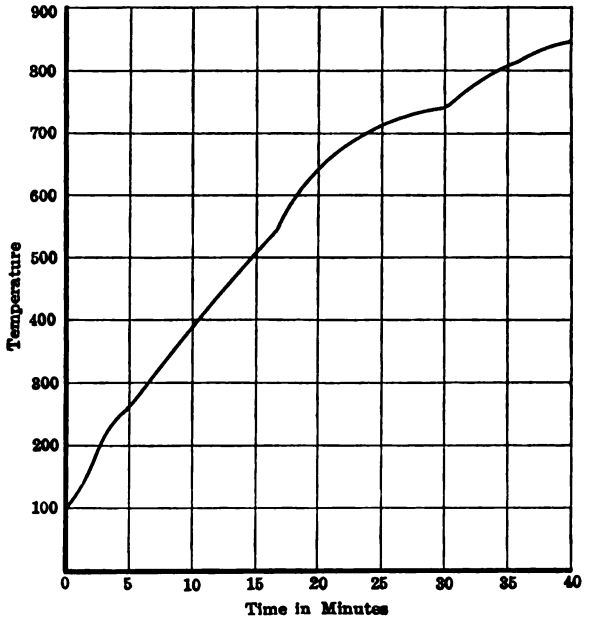


FIG. 5.—Galena-calcium Sulphate Mixture.

degree of fusibility. The percentage of sulphur may be reduced by rough-roasting, by adding a diluent, or by applying both remedies. With a leady copper matte and a down-draft apparatus, iron ore is the best diluent; siliceous ore does not reduce the sulphur-content as effectively; the same is the case with limestone which leaves more sulphur in the sinter than siliceous ore. Thus a matte with Pb, 22 per cent., Cu, 15 per cent.; S, 22 per cent. mixed with about 50 per cent. limestone and a little silica gave a sinter with S, 9 per cent.; siliceous ore alone gave S, 7 per cent.; and equal parts of iron ore and $SiO_2$ gave S, 4 per cent. For pyritous charges limestone is not a satisfactory diluent;

[1] *Met. and Chem. Eng.*, 1912, X, 153, 207.

such ores are liable to cause trouble in down-draft furnaces on account of the sublimation of one molecule of S from pyrite, while in up-draft apparatus the sulphur is practically harmless. On account of the rapidity with which the $SO_2$ formed is withdrawn, there is little occasion for the formation of $SO_3$. Incidentally it may be stated that dissociation at the elevated temperature would decompose the small amounts of $SO_3$ formed. The loss in Pb and Ag experienced in ordinary roasting furnaces becomes less significant in blast roasting; it is smaller in down-draft than in up-draft appliances, as blow-holes, one important source of loss, are absent as in the former, and the time of roasting is shorter. For the success of blast roasting, it is essential the air circulate through the entire charge during the whole of the operation. With a correct percentage of sulphur, this will be the case with a coarse charge; with a fine charge the permeability will depend largely upon the amount of water that has been incorporated; thus, a slimy concentrate or flue dust may require as much as 12 per cent. water for a charge to hold its shape while roasting, while 1/2-in. ore gets along with 2 per cent. water and even less. The fineness and structure of a sinter depend upon the composition of the charge and the temperature of the roast. For ores containing Pb, 40+ per cent. and S, 9 per cent., a good sinter will be formed, if the remaining 50 per cent. are made up of equal parts of $SiO_2$, CaO and Fe; ore remaining lower in Pb may have a charge with $SiO_2$ 30 per cent. some Fe, and little CaO. Two charges, *e.g.*, with Insol, 22.0 per cent., Fe, 17.8 per cent., Pb, 23.0 per cent., S, 18.6 per cent., Zn, 4.3 per cent., and Insol. 20.5 per cent., Fe, 28.8 per cent., Pb, 10.1 per cent., S, 20.4 per cent., Zn, 6.0 per cent., formed, on account of the percentage of S, matte bearing sinters, while two other charges with Insol, 26.0 per cent., Fe, 24.0 per cent., Pb, 17.0 per cent., S, 16.1 per cent., Zn, 4.7 per cent., and Insol, 23.2 per cent., Fe, 19.7 per cent., Pb, 13.8 per cent., S 17.2 per cent., Zn, 5.8 per cent., formed a desirable product. In general, it is necessary to have present enough $SiO_2$ to form a web-like skeleton with the bases and to have enough S for generating the correct amount of heat. In the deep charges of pot-roasting, the cake is liable to be more fused than in the shallow beds of a down-draft apparatus.

The author discusses the ignition of charges in up- and down-draft furnaces, describes the Huntington-Heberlein Savelsberg, Midvale, Dwight-Lloyd and Greenawalt apparatus and modes of operating; of the last drawings are given. For some of the above modifications of blast roasting there are furnished, besides the leading features, some estimates of cost.

C. L. Bryden[1] has furnished a general paper on blast roasting; a

[1] *Min. and Eng. World*, 1912, XXXVI, 1351.

similar article by Kroupa[1] contains as a novelty drawings of the von Schippenbach down-draft furnace with collection of sulphurous gases.[2]

Dwight-Lloyd Straight-Line Machines at Salida, Colo.,[3] are described with details which supplement the general statement given on page 544. The pallet of a large machine is 24 by 42 in. and 4.5 in. deep, and has three herring-bone grates, 8 by 42 in. The grates are now made heavier than formerly and have only four-fifths as many slots as before, the flare from the top to bottom of each slot is also greater. A pallet travels at the rate of 1.6 ft. per minute. The charge consists of rough-roasted pyrite concentrate with S 15 per cent., galena concentrate, raw siliceous sulphide ore, and fine sinter; an average analysis for December, 1911 gave, Pb, 18.0 per cent., Cu, 1.0 per cent., Insol, 24.6 per cent., Fe, 21.2 per cent., Mn, 1.0 per cent., Zn, 7.6 per cent., S, 15.4 per cent.; physically it consists $\frac{3}{4}$ of coarse material (1/2–1 in.) forming a layer 1 in. deep on the grate which is covered with fine material to a depth of from 3.5 to 3 in. deep. The charge is ignited from a suspended coal-fired stove in from 35 to 40 seconds, the coal consumption is 11 lb. per ton of charge. The roast lasts from 12 to 14 minutes, the down-draft is equivalent to 8 in. water; the machine treats 75 tons mixture in 24 hours. The charge-mixture is made up mechanically. There is built in a row a number of hopper-shaped bins, one for each kind of ore; the content of each is discharged by its belt-conveyor on to a main belt which delivers to the center of a cast-iron circular mixing table, 8 ft. in diam., making 2 r.p.m.; stationary blades spread the ore toward the periphery where the now uniform mixture is discharged and elevated to the receiving bins; on the table the mixture is moistened with about 10 per cent. water.

New patents have been issued to A. S. Dwight,[4] relating to the established down-draft machines. Another has been granted[5] for an up-draft in connection with the straight-line down-draft machine. The charge is to be ignited below the grate, and to be held quiescent by means of an endless moving grate above the charge; there are to be upper and lower wind-bases.

F. W. Yost[6] has patented the plan of applying blast or draft to the unkindled instead of the kindled side of a roasting bed; he aims to keep away from the zone of reaction the products of combustion and thus make the process more active. The operations of roasting and sintering may be carried on in two stages, the first with the blast or draft applied

[1] *Oest. Zeitschrift Berg und Hüttenwesen*, 1912, LX, 513, 539, ill.
[2] MINERAL INDUSTRY, 1911, XX, 480.
[3] Correspondent, *Met. Chem. Eng.*, 1912, X, 87.
[4] U. S. Patent Reissues Nos. 13423 and 13424, May 28, 1912; and No. 1027110, May 21, 1912.
[5] U. S. Patent, No. 1021509, March 26, 1912.
[6] U. S. Patent No. 1003682, 1003683, 1003684, Sept. 10, 1911.

to the cool surface to warm the ore and start the roasting, and the second with the blast or draft working in the opposite direction to accomplish the sintering.

*Development of American Water-jacket Lead Blast Furnace.*—Under this heading R. C. Canby[1] discussed the growth of American lead smelting practice before the International Congress of Applied Chemistry held in New York in 1912. The modern lead blast furnace had its beginning at Eureka, Nev., in 1870, where A. Arents introduced the siphon-tap. At the beginning of 1880 the leading features of the present furnace had been developed as exemplified by the smelteries of Salt Lake City, Leadville, Denver and Pueblo, although the capacity of a furnace was still small having a tuyère section of 36×60−80 in. It was at Salt Lake City that through the efforts of Eilers, Hahn and Raht suitable slag-compositions were developed. In the late eighties when sulphide began to replace oxide ores, a beginning was made to collect the matte formed, the earlier small settlers grew in size with the growth of the matte-fall (2–10 per cent.) and the increase of furnace-capacity (42×120 in. at tuyères), and with the latter an increase of the volume of air blown with the furnace. The cleaning effect of a small amount of copper in the matte (2–8 per cent. Cu) was also recognized. Attention was now given to the amount of air required by the furnace, the criterion being an escape of free oxygen from the top of the charge. In the roasting, a gradual change was made from the ordinary hand reverberatory furnace to one provided with a fuse-box; this was abandoned for mechanical roasters, and the latter have been replaced by some blast-roasting device which gave cheaply lump ore without any considerable loss of metal by volatilization. The use of blast roasted lump ore in large furnaces, increasing the smelting power from 150 to 200 and 250 tons of charge in 24 hours made imperative the replacement of hand-feeding by some mechanical device, and the hauling away of slag and matte by steam or electric traction. All these improvements greatly decreased the cost of treatment, *e.g.*, from $4.65 per ton at Denver with a furnace 30×100 in. at tuyères to $2.26 with a furnace 42×120 in. Many interesting details of former and present practice are given in the paper.

*Blast-furnace. Charge Calculations.*—R. Chauvenet[2] takes up in detail some of the calculations required in blast-furnace work. They have been incorporated in his "Chemical Arithmetic and Calculation of Blast-furnace Charge." Lippincott, Philadelphia, 1912.

*Preparation of Blast-furnace Mixture.*—It is the general practice of

[1] *Proc. Eighth Int. Cong. Appl. Chem.*, 1912, Vol. III, p. 1; *Trans. Am. Inst. Min. Eng.*, 1912, XLIV; *Eng. and Min. Journ.*, 1912, XCIV, 746.
[2] *Met. and Chem. Eng.*, 1912, X., 36, 104, 135, 220, 238.

lead smelters to weigh, sample, and analyze the different ores received at a plant, to bed them, to calculate the average compositions of the beds, and to use the beds as ore-mixture cutting down vertically so that each portion shall represent a true average. At the works of the International Smelting and Refining Co., Tooele, [1] Utah, this practice has not been followed. The ores are collected in overhead bins each of which is provided with a weighing device. In making up a charge, a train of cars passes underneath the bins from which the calculated amounts are drawn into the cars and weighed at the same time, thus simplifying and cheapening the handling of ores and fuses. In reply to an editorial[2] commending the careful preparation of charges, A. Eilers[3] states that since 1876 in all the works with which he had been connected all possible care had been given to this phase, and maintains that in treating the great variety of ores a custom smeltery receives, some bedding is indispensable, as in making up a charge one has to consider the physical condition of the ores (coarse, fine, wet, dry), as well as the chemical compositions of the components. In order to simplify the preliminary steps for bedding, ores are classed from a chemical point of view as siliceous, basic and nearly neutral, and as sulphide, oxide and roasted; they are bedded severally if the capacity of the plant is sufficiently large, and the character of the ore warrants it. As to feeding a furnace, Eilers emphasizes the point, discussed some time ago by A. T. Austin[4] that if the furnace is to do proper work no excess of coke may be used over that which is absolutely necessary to carry on reduction and fusion. He takes exception to the idea generally held that a large furnace is not so sensitive to faulty charges as is one of small dimensions, and states that while a large furnace responds more slowly to ill treatment than a small one, the effect is quickly apparent in the slower running, in the formation of bad slags and of obstructions in shaft and crucible, and in the increased cost of smelting.

*Disposal of Waste Slag.*—The disposal of waste slag at the blast-furnaces of Lawrium, Greece, is discussed by J. P. Doanides.[5] There are in operation six circular blast-furnaces, 5 ft. 5 3/4 in. in diameter, with 3 tuyères, 2 1/4 in. in diameter. A furnace puts through in 24 hours from 45 to 60 tons charge with 6.50–7.50 per cent. Pb; 70 per cent. of the charge forms slag assaying $SiO_2$, 35 per cent., Fe, 18, per cent., CaO 15 per cent., $Al_2O_3$, 8 per cent. The furnaces are tapped from the bottom; the slag from two furnaces goes into one forehearth from which it overflows

[1] Editor, *Eng. and Min. Journ.*, 1912, XCIV, 2.
[2] *Eng. and Min. Journ.*, 1912, XCIV, 50.
[3] *Eng. and Min. Journ.*, 1912, XCIV, 147.
[4] MINERAL INDUSTRY, 1907, XVI, 677.
[5] *Revue Universelle des Mines*, 1912, XXVIII, 213.

into a link-chain slag-casting machine, about 65 ft. long, with 190 cast-iron buckets. The belt which makes a round-trip in 5 minutes 5 seconds, has a rise of 8 ft. 6 in. The slag is sprayed while traveling from the fore-hearth, chain and buckets are immersed on the return trip, the slag is delivered into cars and hauled away. Formerly when slag was pulled in pots to the dump, allowed to cool, and then dumped, broken and loaded, there were required eight men for a furnace on the day-shift; at present with the casting machine six men to the work for two furnaces.

*New Smelting Furnaces.*—An additional patent[1] has been granted A. R. Partridge for this furnace.[2] A similar furnace has been patented by A. D. Leduc.[3] E. Fink[4] has added to his rotating oil-fired reverberatory smelting furnace several rows of converting of tuyères; he expects to treat in it mixed sulphide ores, volatilizing lead and zinc, and recovering copper in the form of white metal or blister copper.

*Bag Filtration.*[5]—The use of bags for the recovery of fume from furnace gas had its origin in the production of zinc oxide; its first application to the recovery of lead is found in connection with the ore-hearth treatment of lead ores in the Mississippi valley; the first permanent bag house in connection with the lead blast furnace was erected at the Globe works, Denver, in 1887. Since then this example has been followed by other works, not so much to save lead and silver, as to comply with the demands of agricultural interests which insisted that furnace fumes be prevented from settling upon the land to the detriment of plant and animal life.

The author discusses two characteristic examples, the bag house and its working at Murray, Utah, where charges low in lead (10–12 per cent.) and high in precious metal are treated, and the same at Omaha, Neb., which collects the fumes from charges running high in lead (as much as 40 per cent.) and in silver. Both plants are described, drawings of the Murray installation accompany the text.

The bag house of the Murray smeltery is 216 ft. 6 in. by 90 ft. 6 in.; there are four compartments separated by brick partitions extending from the brick floor to the roof. Beneath the thimble-floor each compartment is divided into four chambers receiving cooled furnace gases from a 16 by 16 ft. distributing flue which is connected with a fan capable of handilng 1500 cu. ft. gas per minute at 1 in. water pressure. A compartment has 1008 steel thimbles, 17 in. in diameter, and 10 in. high, which receive bags 18 in. in diameter and 30 ft. long. The filtered gases are exhausted

[1] U. S. Patent, No. 1025922, May 7, 1912.
[2] MINERAL INDUSTRY, 1910, XIX, 451.
[3] U. S. Patent, No. 1025531, May 7, 1912.
[4] *Min. and Eng. World*, 1912, XXXVII, 797.
[5] A. Eilers, *Eighth Int. Cong. Appl. Chem.*, 1912, III, 81; *Trans. Am. Inst. Min. Eng.*, 1912, XLIII; *Eng. and Min Journ.*, 1912, XCIV, 965.

by a stack 6 ft. in diameter and 78 ft. high. The filtering surface is 3.45 sq. ft. per cubic foot of gas per minute. When one compartment is shut down for sintering the fume, there remain available 2.59 sq. ft. of surface per cubic foot of gas per minute; the basis of calculation for bag house in lead blast-furnace smelting is 2.5 sq. ft. In 1907 cotton bags were used costing $2.136 a piece, they lasted 17 months, 11 days; these were replaced in 1909 by woolen bags costing $4.7185 a piece, they have been in place for two years and appear to be intact. The blast-furnace gases pass through 70 ft. of sheet-iron flue and 795 ft. of brick flue, and reach the fan with a temperature averaging in January 27° C. and in August 58.5° C; the average of three years was 38.5° C., a temperature sufficiently low to have caused the sulphuric acid vapors to condense and separate, analysis of gas entering the bag house when there was a decided deterioriation of bags showing only 0.003 per cent. $SO_3$.

The paper gives many details of construction for which the reader is referred to the original.

An average analysis of 1124 tons unburned fume showed Au 0.0149 oz., Ag 2.62 oz., Pb 28.42 per cent., Cu 0.058 per cent. $SiO_2$ 2.9 per cent., Zn 3.2 per cent., S 5.2 per cent., As 36.6 per cent., Fe 5.1 per cent.; after sintering the fume assayed Au 0.014 oz., Ag 2.4 oz., Pb 27.3 per cent., Cu 0.05 per cent., $SiO_2$ 2.5 per cent., Zn 4.2 per cent., S 4.2 per cent., As 33.5 per cent.; that is, with the exception of the elimination of some C and As there was little chemical change effected by the operation. There was recovered in the 1124 tons of fume, 0.097 per cent. of the Au of the charge, 0.085 per cent. of the Ag, 1.276 per cent. of the Pb, and 0.071 per cent. of the Cu; the fume formed 0.415 per cent. of the weight of the charge smelted. The total cost of recovery of 13,857,645 lb. of fume obtained in smelting 1,606,857 tons' charge in 4 years and 8 months was $146,143.43; the value of the metal extracted $152,690.52, the gain therefore $6547.09. From this has to be deducted interest and amortization amounting to $65,293.37, which gives a net loss in 4 years and 8 months of $58,746.28. Considering that the recovery of $As_2O_3$ at $5.20 per ton would diminish the loss by $34,654.00 there still remains a final loss of $24,101.28. The bag house at Murray does not pay. The loss is borne on account of the freedom it insures against complaints from agricultural sources.

At the Omaha plant there are three bag houses, for the recovery of values from the acid converters treating lead-copper mate (Cu, 45 per cent., Pb, 23 per cent., S, 18 per cent.), for the blast-furnace divisions, and for the zinc-oxide plant.

The converter bag house, 102×60.8×40 ft., serving two acid upright and one Pierce-Smith basic converters has two compartments, receives

its gases through a pointed sheet-iron flue 1250 ft. long; there are installed 940 woolen bags 18 in. in diameter and 28 ft. long; one set filters 1600 tons $PbSO_4$-fume which comes from 4500 tons blister copper. The life of a bag is governed by the cooling of the gases and by their quick withdrawal when filtered; analyses gave $SO_3$ at the converter 0.038 per cent. and 0.027 per cent.; at the fan 0.020 per cent. and 0.025 per cent., showing the condensation and settling of $H_2SO_4$. The following is a record of temperature of converter gases with the outside air at 27° C: back of converter 375° C., at 80 ft. from converter 292°, at 200 ft. 240°, at 400 ft. 199°, at 600 ft. 174°, at 800 ft. 149°, at 1100 ft. 130°, at fan 119°, at baghouse 67°, at stack 58° C; the average temperature of the bag house was 60° C. Some fume analyses are subjoined.

FUME ANALYSES.

| | Ag. Oz. per Ton | Pb, %. | Zn, %. | Combined $SO_3$. | Uncombined $SO_3$. | As. | Sb. | Te. | Se. |
|---|---|---|---|---|---|---|---|---|---|
| From converter | | | | | | | | | |
| 200 ft..... | 4.2 | 56.0 | 1.6 | 25.13 | 0.25 | ..... | ..... | ..... | ..... |
| 400 ft..... | 3.0 | 60.0 | 1.6 | 23.13 | 0.55 | ..... | ..... | ..... | ..... |
| 600 ft..... | 2.4 | 64.2 | 1.3 | 22.82 | 0.15 | ..... | ..... | ..... | ..... |
| 800 ft..... | 2.0 | 64.6 | 1.3 | 22.60 | 0.00 | ..... | ..... | ..... | ..... |
| 1100 ft..... | 2.1 | 63.0 | 1.5 | 23.33 | 0.00 | ..... | ..... | ..... | ..... |
| 1200 ft..... | 1.6 | 64.4 | 1.6 | 20.60 | 0.00 | ..... | ..... | ..... | ..... |
| Caught in bag house ..... | 2.8 | 66.0 | 1.9 | 21.63 | ..... | 2.0 | 0.2 | 0.2 | 0.24 |

In February, 1911, there was produced 1607 tons blister copper, and recovered 615 tons fume; or 1 ton blister copper gives 0.368 ton fume (=0.221 tons lead). The cost sheet shows that in treating 21,544 tons matte (Au 0.17 oz. Ag 98.1 oz., Pb 20.9 per cent., Cu 43.1 per cent,. NiCo, 0.4 per cent., $SiO_2$ 0.3 per cent., Fe 8.0 per cent., Zn 2.5. per cent., S 15.5 per cent., As 1.7, per cent., Sb 0.76 per cent.) there were recovered 3478 tons fume giving a net profit of $98,711.50.

In the blast-furnace division there are two bag houses similar to those in the converter department; the length of the sheet-iron flue conducting the gases from the furnaces to the bag house is 1400 ft. Four per cent. of the lead in the blast-furnace charges went into the bag house. The raw fume had the following composition: Pb 52.5 per cent., Cu trace, Zn 3.0 per cent., S 5.4 per cent., As 14.2 per cent., Sb 1.6 per cent., Te some, Ag 10 oz. per ton. The cost sheets show a profit of $7,684.00 in the treatment of 74,112 tons of charge.

The zinc oxide department recovers in 120 bags about 40 tons crude zinc oxide per month which contains Zn 53.0 per cent., Pb 20.0 per cent., Sb 1.5 per cent., As 0.3 per cent.

At Murray there is a loss, at Omaha a profit in using a bag house.

*Shaking of Bags.*—A shaking device for filter bags has been recently patented by A. J. Meier.[1] The bags are suspended severally by springs and receive a vertical and a sidewise motion. Before shaking, the flow of gas into the bags is stopped by means of a damper moved by a cam-driven device which results in the pressure inside and outside of the bags being equalized and thereby the separation of the facilitated. In shaking, a rod which connects a row of bags is pushed downward and sideways by means of a cam and suddenly released when the springs draw it back quickly to its orginal position. A row of bags is thus subjected to a vertical and lateral motion, the combined action of which quickly loosens the dust. There is provided a cam for each rod, and the cams are driven together from one line-shaft.

*Electric Condensation.*[2]—The Cottrell process has been extended by the inventor[3] to the collection of dust in roaster gases previous to their conversion into sulphuric acid. It is proposed to collect the dust on a mist, *e.g.*, of sulphuric acid and water, artificially produced, and to remove this mist by an electric discharge. The process of forming a mist may be repeated in successive intervals, and the purification of the gas thus made perfect.

W. R. Whitney patented[4] a process for oxidizing the $SO_2$ in furnace gases before they enter the Cottrell condensing apparatus. The gases are to be mixed with steam and nitrous vapors in a chamber where sulphuric acid, nitroxyl and similar products are formed which are readily precipitated when passing between the high-tension poles of the Cottrell process.

In a paper upon electric fume condensation, F.G. Cottrell[5] notes the progress that has been made in this process. Two convincing illustrations of an experimental plant for 3000 cu. ft. gas per minute show the effect upon the condensation of fume from the basic converter treating lead-bearing matte at Garfield, Utah. In the first photograph is seen a white cloud of fume issuing from the tubular collecting-electrode with the discharge-electrode in the center; in the second the fume has disappeared as soon as the current has been turned on. A full-scale working unit was completed June, 1912, and is now in successful operation.

*Wet Condensation.*—W. Feld[6] has constructed a gas-washer which consists of a series of superimposed chambers, each with four gas-intakes. In the center revolves at 120 r.p.m. a shaft having for each chamber a set of concentric cones attached to a hub and dipping into the seal-

[1] U. S. Patent, No. 1030477, June 25, 1912; *Eng. and Min. Journ.*, 1912, XCIV, 683; *Met. and Chem. Eng.*, 1912, X, 555.
[2] MINERAL INDUSTRY, 1911, XX, 489.
[3] U. S. Patent, No. 1016476, February 6, 1912.
[4] U. S. Patent, No. 1022012, April 2, 1912.
[5] *Tr. Am. Inst. Min. Eng.*, 1912, XLIII, 512, 755.
[6] *Met. Chem. Eng.*, 1912, X, 436.

water. By the rotation of the shaft, the water is drawn up on the inner edges of the cones and thrown off tangentially at the outer against the wall of the chamber. The water forms in the chamber a mist through which the ascending gases have to travel; fresh water is continuously admitted at the top of the condensing tower, travels downward, and overflows at the bottom carrying with it dissolved gas and condensed dust. This washer, intended primarily for the condensation of the volatile matter of a by-product coking oven, has been used in a lead smelting plant with the result that 99 per cent. of all the dust has been recovered in the form of a mud which when dried assayed Pb 70 per cent.

*Neutralization of Sulphurous Gases.*—A method of neutralizing sulphurous gases by Sörensen and Westley is described by the latter.[1] It consists in having furnace gases act upon finely divided chilled lead or copper blast-furnace slag, when the acids attack the slag, and form sulphites and sulphates, sulphur separating at the same time. Three kinds of apparatus have been tried, two vertical, 4 ft. square, with a combined height of 77 ft. provided with narrow staggered shelves set 3–4 ft. apart; one revolving cylinder, 10 ft. long and 30 in. in diameter, with longitudinal ribs receiving a charge slag and turning it over until it became inactive; another cylinder 36 ft. long and 12 ft. in diameter, similarly equipped with ribs, but fed continuously. In all three apparatus the gases were introduced at one end and drawn off by means of a fan at the other. The following table gives a summary of the results obtained.

RESULTS OF SÖRENSEN-WESTLEY PROCESS.

| | | | | | |
|---|---|---|---|---|---|
| Period of run, minutes | 70.0 | 57.0 | 200.0 | 280.0 | 110.0 |
| Temperature of gas entering, °C | 121.0 | 218.0 | 210.0 | 197.0 | 121.0 |
| Temperature of gas leaving, °C | 25.0 | 27.0 | 27.0 | 34.0 | 38.0 |
| Temperature of liquor discharge, °C | 38.0 | 48.0 | ..... | 54.0 | 54.0 |
| Water used per minute, pounds | 620.0 | 396.0 | 359.0 | 138.0 | 270.0 |
| Total Fe in solution, pounds | 479.0 | 208.0 | 604.0 | 732.0 | 652.0 |
| Total S in solution, pounds | 309.0 | 307.0 | 656.0 | 594.0 | 548.0 |
| Rate of adding slag, per minute | 30.0 | 35.3 | 22.3 | 14.2 | 50.0 |
| Slag required, theoretical, per minute | 44.3 | 19.4 | 30.8 | 37.8 | 37.0 |
| Total available slag, discharged, pounds | 2120.0 | 2015.0 | 4470.0 | 3998.0 | 5512.0 |
| $SO_2$ absorbed, per cent | 38.2 | 46.8 | 39.0 | 19.8 | 43.3 |
| Analyses: | | | | | |
| Fe, mg. in 100 c.c. solution | 1008.0 | 924.0 | 1053.0 | 1897.0 | 2194.0 |
| S, mg. in 100 c.c. solution | 710.0 | 1360.0 | 1143.0 | 1540.0 | 1837.0 |
| Cu, mg. in 100 c.c. solution | 21.4 | 10.5 | 15.0 | 15.0 | 9.1 |

*The Thiogen Process.*—This process[2] which aims to reduce $SO_2$ to S is stated by Eddy[3] to have been successful at the smeltery of the Penn Mining Co., Campo Seco, Calif., in reducing the sulphur-content of the gases from two 11.5-ft. MacDougall furnaces to 1 in 50,000 parts. The experimental plant is shown in Fig. 6.[4] The roaster gas enters a

[1] *Journ. Ind. Eng. Chem.*, 1912, IV, 725; *Min. and Eng. World*, 1912, XXXVII, 709; *Min. and Sci. Press*, 1912, CV, 524.

[2] MINERAL INDUSTRY, 1911, XX, 491; *Met. and Chem. Eng.*, 1912, X, 710; *Min. and Sci. Press*, 1912, CIV, 497.

[3] *Eng. and Min. Journ.*, 1912, XCIII, 873.

[4] *Eng. and Min. Journ.*, 1912, XCIII, 874.

dull red mixing chamber into which is injected steam and vaporized oil; the mixture passes through a contact flue in which are placed at intervals checker-work plates, the open places of which are loosely filled with a contact substance consisting of plaster of Paris reduced to calcium sulphide by first mixing with sawdust and then burning. All the $SO_2$ is said to be reduced in the contact-flue, the S-vapor is cooled in the condensing chamber by a water spray, and most of the flour of sulphur collected. Flue dust is recovered on the floor in the contact flue, condensed water flows into the drainage-channels of the condensing chamber, the harmless gases pass off through the stack. An illustrated description

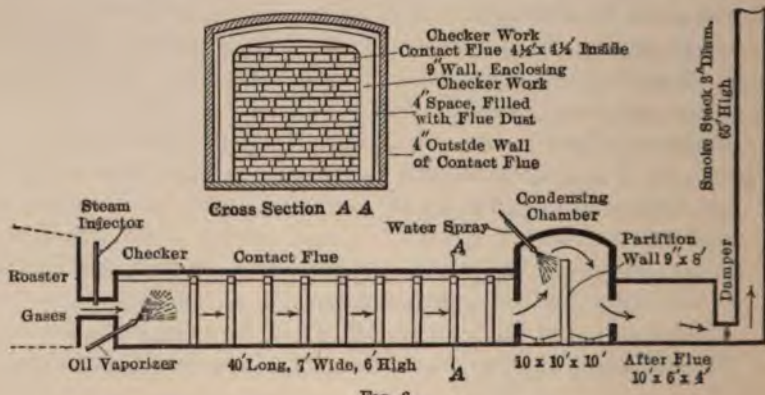


FIG. 6

of the laboratory apparatus used by the inventor for showing the reactions that take place in the process is given in Engineering and Mining Journal, 1912, XCIV, 445.

*Lead Poisoning.*—J. O. Clifford[1] has written an interesting article, general in character, upon this important subject. He discusses the manner in which lead enters the human body, the symptoms by which lead poisoning may be detected, the effects of lead, the means of preventing lead poisoning, gives in brief the regulations of the leading European countries, and expresses the hope that federal supervision will be exercised so as to protect all employees having to deal with lead in some form or other.

*Treatment of Flue Dust.*—A symposium upon the subject of sintering iron ores was given at the February meeting of the American Institute of Mining Engineers; it brought out the present practice of dealing with finely divided iron-bearing ore and flue dust. The papers by Klugh, Landis, Vogel, Richards and Hansell contain many points of interest to

[1] *Min. and Sci. Press*, 1912, CV, 9.

the lead smelter. Another paper upon this subject is one by West[1] which describes the furnace construction by the author for agglomerating intermittently fine iron ore.

*Wet Process for the Separation of Lead and Antimony Sulphides.*—The investigation of Wagemann upon the freezing-point curve of $PbS-Sb_2S_3$, has been discussed under lead and antimonious sulphide (p540). The same author experimented upon a process for separating these sulphides in the wet way. The only solvent to be considered is $Na_2S$ which readily dissolves $Sb_2S_3$ and $Sb_2S_5$, but does not attack PbS. He found that the compound $Pb_2Sb_2S_5$ was dissolved by a hot solution of $Na_2S$, the reaction taking place being $Pb_2Sb_2S_5+2Na_2S=Na_4Sb_2S_5+2PbS$; the eutectic $Sb_2S_3-Pb_2Sb_2S_5$ is of course soluble; from the solid solutions of $Pb_2Sb_2S_5$ in PbS, the antimony is readily dissolved leaving behind PbS up to a residue of PbS with 4.1 per cent. $Sb_2S_3$. In order to obtain a quantitative separation of the two sulphides, it is necessary to fuse with the lead ore enough $Sb_2S_3$ to form the compound $Pb_2Sb_2S_5$. In the process iron is separated quantitatively as FeS. The dissolving power of $Na_2S$ is strengthened by an addition of $Na_2SO_4$.

## Desilverization.

*Parkes Process.*—E. F. Eurich discussed the development of the Parkes process in the United States.[2] In 1864 E. Balbach of Newark, N. J., patented a process for desilverizing lead bullion by means of zinc; in 1867 E. Balbach, Jr., took out a patent for the recovery of zinc from zinc-silver-lead crust in a movable black-lead retort with neck. The process as carried out at Newark consisted in purifying lead bullion by melting in a reverberatory furnace with sloping cast-iron hearth, the lead running into a kettle charged with metallic zinc, in stirring the mixture, ladling it into molds, heating the bars in a second furnace, refining the liquated lead in a brick reverberatory furnace, distilling zinc-silver-lead crust in a graphite retort, and cupelling the enriched lead. About 1872 the Balbach process was modified to resemble the Parkes process as practised to-day. In 1873 there were in operation in the United States 14 desilverizing plants using various processes; the works near Pittsburgh, Pa., and St. Louis, Mo., used the Parkes process as practised at present, later followed the refineries at Salt Lake City, Omaha and San Francisco; the last two with the Newark and Chicago works are the leading plants now in operation.

The characteristic of all American plants is the terrace-arrangement:

[1] *Iron Age*, 1912, XC, 954; *Eng. and Min. Journ.*, 1912, XCIV, 459.
[2] *Proc. Eighth Intl. Congr. Appl. Chem.*, 1912, III, 79; *Trans. A. I. M. E.*, 1912, XLIV.

softening furnace, desilverizing kettle, refining furnace and the molding floor. The softening furnace, as early as 1873, had a hearth built into a boiler iron pan; the side walls are water-cooled to counteract the corrosion of the lining, the advent of magnesite brick has made water-cooling less necessary than was formerly the case when the hearth was built of fire-brick. The first furnaces had a capacity of 10 tons lead bullion and this was increased to 90 tons, the economic limit for hand-charging; with the introduction of mechanical charging the capacity has been increased to 240 tons. The time required for softening a 240-ton charge is not any longer than that for a 10-ton charge. Softening has been much simplified since blast-furnace managers ship only drossed bullion. The capacity of the desilverizing kettles has been increased from 10 to 60 and 70 tons. In 1877, A. Steitz of St. Louis invented his siphon for discharging desilverized lead; this was universally used until it began to be replaced by a horizontal centrifugal pump driven by an electric motor. This last device does away with limiting the depth of a kettle to 40 in. Stirring the zinc into the lead is now generally accomplished by means of the Howard machine instead of by means of paddles manipulated by hand. Liquation of silver crust, first carried on in a reverberatory furnace and later in a kettle with spout, have been replaced since 1894 by the Howard press.

The time required for disilverizing, originally for 15 to 20 hours, has been reduced by the Howard machine to about 10 hours. Refining of disilverized lead is now carried on wholly in the reverberatory furnace; steaming, according to the method of Cordurié common in Europe, was practised at the refining works of the Pueblo Smelting and Refining Co. Running refined lead from the reverberatory furnace direct into molds is practised at some works; at others the refined lead is collected in a market kettle from which it is transferred by means of a siphon or a centrifugal pump into molds placed on the floor in a semi-circle or on a link-belt conveyor. Ladling refined lead held its own until 1876. The distillation of zinc-silver-crust has been carried on since 1870 in the Faber duFaur tilting retort, the capacity of the retort has been increased from the original 250 lb. to 1400 lb. crust; coal-, coke-, and gas-firing have been replaced by oil-firing which has reduced the time of distillation and lengthened the life of the retort. The English type of cupelling has always been the standard; however, the working door has been removed from the side to the end of the furnace and placed beneath the flue leading off the gases, the stationary test has been exchanged for one that can be tilted, the capacity of the test has been increased from 1 ton to 6 tons, the bone-ash lining has given way to clay-limestone mixture, to cement, to cement-limestone and lastly to magnesite brick; water

jacketing the sides and the front has greatly lengthened the life of the lining.

Thus the improvements made in the United States upon the Parkes process have been mainly in the simplification of the operations, in the increase of capacity of the units, and the consequent cheapening of the cost of desilverization.

*Desilverizing Kettle.*—In a general article on foundry-practice at smelting works, H. M. Lane[1] gives an illustrated description of the manner of casting a desilverizing kettle, bottom down, in a loam mold with brickwork supporting the structure.

*Distilling Zinc Crust in Vacuo*—H. Turner[2] found in his recent study of the behavior of certain alloys when heated *in vacuo* that he could separate zinc from copper in certain brasses by heating them a few degrees above their melting-points; he removed zinc in the same way from the alloy of zinc and iron formed in the refining of crude spelter. Preliminary experiments have proved that heating zinc-silver-lead *in vacuo* to 700° C. caused the zinc to distil over carrying with it small amounts of silver and lead.

*Dezincification of Lead.*—The lead bullion desilverized by the Parkes process retains about 0.6 per cent. Zn which is usually removed by an oxidizing fusion or by steaming. A new process of F. Roderbourg[3] moves the zinc by stirring into the mental bath a mixture of $ZnCl_2$ and PbO which acts as follows: $Zn+PbO+ZnCl_2=Zn+PbCl_2+ZnO=ZnCl_2+ZnO+Pb$. Thus a kettle holding about 0.5 ton zinc requires about 50 kg. of a double salt of $ZnCl_2$ and NaCl, and 500 kg. oxidized lead ore or litharge free from Cu and Ag, and double salt is used repeatedly; at intervals it has to be purified by solution in water to separate the ZnO, and then evaporated to dryness. The inventor holds that the process is applicable to the treatment of zinc-silver-lead crusts holding from 10 to 25 per cent. Zn.

*Desilverization at Port Pirie, South Australia.*—W. Poole[4] describes the operation of the Parkes process at this important plant.[5] The leading features of the mode of working are the same as those common in the United States.

1. Melting and Drossing of Lead Bullion.—The operation is carried on in the reverberatory furnace in charges averaging 38 tons of lead bullion. Charging takes 2 to 3 hours; melting and drossing 6 to 12, or an average of 8 hours. The dross skimmed from a charge weighs 3000 to 6000 lb. and contains Pb 70 to 80 per cent., Cu 6 to 12 per cent., Ag

[1] *Eng. and Min. Journ.*, 1912, XCIII, 321.
[2] *Journ. Inst. Met.*, 1912, VII, 105.
[3] German patent, No. 241483; *Metallurgie*, 1912, IX, 239.
[4] *Mines and Minerals*, 1912, XXXII, 423.
[5] MINERAL INDUSTRY, 1907, XVI, 671; 1908, XVII, 605; 1910, XIX, 459.

45 to 60 oz. per ton. An average composition is Pb 70 per cent., Cu 8 per cent., Fe 0.8 per cent., Zn 1.0 per cent., S 5.0 per cent., As 0.5 per cent., Sb 0.7 per cent., Insol 2.0 per cent., Ag 58 oz. per ton and Au 0.015 oz. per ton. The drossed lead assays, Cu 0.125 per cent., As 0.094 per cent., Sb 0.18 per cent., Ag 70 to 80 oz. per ton and Au 0.05 oz. per ton.

2. Softening.—The drossed lead is run into a reverberatory furnace of the same size as the drossing furnace, the sides however are water-jacketed. With the drossed lead are worked from 50 to 80 bars of antimonial lead containing small amounts of silver which can be removed at a profit. The furnace is strongly fired for 6 hours, cooled and skimmed; the operations are repeated two or three times when all the Sb will have been scorified. The first antimony skimming taken weighs 1300–1400 lb., the second 1400–1600 lb., and the third 700 lb. Softening takes 12 to 16 hours, the coal consumption is 3 per cent. of the weight of the bullion. The skimming assays, Pb 70 to 85 per cent., Sb 7 to 12 per cent., As 0.5 to 1.5 per cent., Ag 1 to 5 oz. per ton; an average figure is Pb 73.8 per cent., Sb 9 per cent., As 1.2 per cent., and Ag 3 oz. per ton. The softened lead retains Cu 0.10 to 0.14 per cent., Sb 0.05 to 0.10 per cent., As a trace. The skimming is mixed with coal and melted in a reverberatory furnace with hearth 11 ft. × 6 ft. 6 in., built into an iron pan, not water-jacketed. In 24 hours there are smelted 12 charges of 2800 lb. skimming and 110 lb. each of powdered coal and coke breeze; there are produced 100 to 150 bars lead bullion (Cu 0.12 per cent., Sb 0.66 per cent., Zn 0.005 per cent., As trace), and 800 to 13,000 lb. desilverized antimony skimming assaying Pb 52 per cent., Sb 27 per cent., As 5.5 per cent., $SiO_2$ 0.7 per cent., and Ag 2 oz. per ton.

The desilverized skimming is smelted in a blast furnace, 32 by 48 in. at tuyères and of 10 ft. 6 in. working height, having 4 tuyères 3 in. in diameter. In 8 hours there are fed 37 charges of 450 lb. skimming, 250 lb. foul blast-furnace slag, 10 lb. scrap iron, and 90 lb. coke, which produce 70 to 80 bars of hard lead, some speise and 5 to 10 tons of waste slag. The slag made analyzes $SiO_2$ 30.5 per cent., FeO 26.9 per cent., MnO 3.8 per cent., CaO 9.5 per cent., $Al_2O_3$ 17.0 per cent., ZnO 0.5 per cent., Sb+Pb 6.2 per cent., and Ag 1 oz. per ton; the antimonial lead, Pb 76. per cent., Sb 21.5 per cent., As 1.8 per cent., Zn 0.1 per cent., Cu 0.2 per cent., and Ag 2 oz. per ton. The lead from the blast furnace is put into a kettle 4 ft. in diameter, is cooled, drossed, and ladled into molds through an iron ring, 3 ft. in diameter, 18 in. deep and 1 in. thick. The dross goes to the ore-smelting department.

3. Freeing Softened Bullion from Copper and Precious Metals.—Contrary to American practice the gold is recovered from the lead in the form of a gold crust and worked up separately.

3a. Gold-zinc—The softened lead bullion is run into the desilverizing kettle, where 100 to 200 lb. of dross assaying 85 oz. Ag per ton are skimmed off. Two additions of zinc are made for gold-zincking, the first addition is 250 lb., the second varies with the gold left in the lead, but usually amounts to 150 lb. scrap zinc or 120 lb. spelter. The two skimmings containing little gold are combined and serve as first gold-zinc additions for another kettle. This is then freed from remaining gold by a second gold-zinc in the form of scrap zinc or spelter. The concentrated gold crusts from several kettles are combined, freed from adhering lead by means of the Howard press, and retorted, a charge taking four hours. No metallic zinc is recovered, but only blue powder; the dross floating on the lead in the retort is skimmed, and the enriched lead with Ag 225 oz. per ton and Au 7 oz. per ton ladled into bars. These are stacked until about 1600 lb. have been accumulated or enough to fill a desilverizing kettle; they are then melted down, the temperature is raised, the dross is stirred to free it from adhering lead, skimmed, pressed and later liquated. The lead is zincked, the zinc crust formed now rich in Au, is retorted without previous pressing, and the retort bullion cupelled.

3b. Silver-zinc.—To the lead bullion freed from gold and copper 700 lb. spelter (or in part unsaturated zinc-silver-lead crust from a preceding charge) are added to extract the bulk of the silver in a saturated zinc-silver-lead crust to be pressed and retorted; a second addition of 700 lb. spelter reduces the Ag-content of the lead to 0.3–0.4 oz. per ton, when a third addition brings it down to the desired amount. Unsaturated crusts go back into the process.

The time consumed in extracting both gold and silver from a kettle-charge is 32 hours; 3.2 per cent. of coal are required.

The lead bullion from the softening furnaces assays Au, 0.03 to 0.50 oz., Ag 72 to 82 oz., Cu 0.12 per cent., Sb 0.089 per cent. and As 2 per cent.; after the first gold-zinc which saturates the lead with zinc, the second gold-zinc reduces the Au to 0.01 oz. or trace and the Ag to 68 to 75 oz.; the first silver-zinc leaves the lead bullion with no Au and Ag 20 to 30 oz.; the second silver-zinc with Ag 0.3 to 0.5 oz., Zn 0.56 per cent., Cu 0.00026 per cent. and Sb 0.00325 per cent.

4. Refining Desilverized Lead.—The refining is carried on in a reverberatory furnace in about 16 hours with a coal consumption of 4 per cent. of the weight of the lead. Two skimmings are taken, the first assays Pb 85 per cent., Zn 10 per cent., Ag 0.1 oz. per ton. The refined lead is run into a merchant kettle of 35 tons capacity and molded in about 4 hours by siphoning into two sizes of molds; the larger bars weighing 180 lb. go to China, the smaller weighing 100 lb. to Europe.

ANALYSES OF REFINED LEAD.

| | | | |
|---|---|---|---|
| [1]Pb (difference) | 99.993086 | 99.994613 | 99.99366 |
| Ag | 0.001710 | 0.001220 | 0.00096 |
| Cu | 0.000324 | 0.000277 | 0.00026 |
| Zn | 0.001710 | 0.000926 | 0.00187 |
| Sb | 0.003170 | 0.002970 | 0.00325 |

5. Treatment of Gold Crust.—The dross referred to above is melted down in a cupelling furnace in charges of 1200 lb. with additions of 400 lb. of litharge; the rising impurities are skimmed and go to the blast furnace, while the rich lead bullion is ladled into bars to be worked in the concentration-cupelling furnace. The retort bullion obtained in the treatment of gold crust assays Au 12 oz., Ag 250 to 300 oz. per ton; it goes to the concentration-cupelling furnaces where it is enriched to Au 480 to 640 oz. and Ag 16,000 oz. per ton, and then finished in another furnace furnishing doré silver with 4 thousandths Au.

6. Treatment of Silver Crusts.—The retort furnaces[2] are gas-fired and have regenerators the valves of which are reversed hourly. A graphite retort is 3 ft. 6 in. high and 2 ft. in diameter and lasts 50 to 60 charges; it has a cylindrical sheet-iron inclined condenser with tap- and vent-holes. A charge of 1200 lb. crust is treated in 10.5 to 12 hours. The retort bullion, 34 per cent. of the charge, is ladled into molds; it assays Ag 3000 to 3500 oz. per ton, Au trace, Zn 1.3 to 3.3 per cent.; the dross formed, weighing 3 per cent. of the charge, assays Ag 2200 to 2500 oz. per ton and Pb 55 to 60 per cent.; the condensed zinc forms about 10.5 per cent. of the charge. The coal consumed equals 18 per cent. of the weight of the crust. The retort dross is smelted. Four charges, each consisting of 750 lb. of dross 500 lb. of litharge, 25 lb. of coal, are worked in 8 hours in a reverberatory furnace holding a bath of 5 tons of lead; there are produced 2200 to 2300 lb. of slag (Ag 300 oz. per ton, Pb 50 per cent., Zn 34 per cent. which goes to the blast furnace and the lead bullion (Ag 3000 oz. per ton) which is cupelled.

7. Cupellation.—This is done in a furnace with fire-place at one end, and the working-door and flue at the other. The test is elliptical, 4 by 5 ft. and 12 in. deep. The filling material: marble 300 lb., limestone 120, Portland cement 120, fire-clay 60 lb., is tamped 9 in. wide at the breast and 4 in. wide at the back and sides. A concentrating test is water-cooled by a 1-in. pipe imbedded in the filling of the sides and back, and by a water-jacket at the breast; the furnace enriches the lead-bullion to 50 per cent. Ag, and makes 1800 lb. litharge in 8 hours. A finishing test has the same lining as the concentrating test, the first only being water-cooled. The silver is cast into bars weighing 700 oz. and assaying 998.5

[1] Refined lead with 99.99 . . . per cent. Pb can represent only selected lots.
[2] Drawing, MINERAL INDUSTRY, 1907, XVI, 672.

to 999. 2 thousandths in fineness; they are melted in graphite crucibles in charges of 2000 oz., copper is added to reduce the fineness to 996.0 or 996.2; the shipping bars weigh 1020 oz.

8. Sulphuric Acid Plant.—Details lie outside of the scope of this review.

*Cupellation.*—R. C. Benner and M. L. Hartmann[1] have published some interesting notes on the early history of cupelling.

Drawings of a reverberatory refining furnace for the treatment of the gold precipitate from the Buffalo cyanide mill, Cobalt, Ont., have been published by W. A. Megraw.[2]

C. J. Brooks[3] describes with drawings a small oil-fired portable cupelling furnace for the treatment of gold-bearing lead obtained from the fusion of acid-treated zinc-box precipitate with litharge and charcoal. The test-ring, 21 in. in diameter and 4 in. deep, is supported by a T-shaped holder and rests upon an angle-iron stand. It is covered by a cap molded from a mixture (50 parts of asbestos and 40 parts of fire-clay and fire-brick) in which are imbedded 1/2-in. wires. A Wells No. 2 oil-burner supplies the heat, a steam-jet furnishing the necessary oxygen. Charges are melted until the test is filled with lead, *i.e.*, about 50 lb.; cupellation is then started and carried on as in the English plan until the test is filled with doré silver, about 953 thousandths fine. In 12 hours there are cupelled 170 lb. of lead bullion assaying 13.3 per cent. precious metal, or 150 lb. of gold bullion with 83.6 per cent. AgAu. The litharge produced assays about 600 oz. AgAu per ton; the oil consumption is 6.5 gal. per 100 lb. of lead cupelled.

*Silver-loss in Cupelling.*—In assaying lead bullion by cupellation, silver losses are caused by volatilization and cupel-absorption. Nothing definite is known about the form in which silver follows the litharge into the cupel. Kohlmeyer[4] finds that molten litharge can hold in solution from 3 to 6 per cent. of some oxide of silver the composition of which is not known, also that the freezing point of the litharge is thereby lowered to 840° C, *i.e.*, by 45°.

## Electrodeposition of Lead

Photomicrographs of cathode lead produced in the laboratory under varying conditions have been published by Wäser and Kühnel.[5]

Mathers and Overman[6] have studied the influences of addition substances (inorganic, essential oils, resins and gums, sugars and starches,

[1] *Min. and Sci. Press*, 1912, CIV, 50.
[2] *Eng. and Min. Journ.*, 1912, XCIV, 840.
[3] *Min. Mag.*, 1912, VI, 193; *Min. and Eng. World*, 1912, XXXVII, 18.
[4] *Chem. Zeit.*, 1912, XXXVI, 1079.
[5] *Electrochemische Ztschft.*, 1912, XVIII, 151, 211.
[6] *Trans. Am. Electrochem. Soc.*, April, 1912.

alkaloids and their derivatives, glucosides, proteids and nitrogenous animal substances, ferments and enzymes, phenols and miscellaneous substances) upon the character of the cathode lead deposited from an electrolyte of lead perchlorate containing free hydrochloric acid. Only some of the organic compounds showed beneficial action, and these contain the hydroxyl group. The addition substances arranged in their order of beneficial action are: clove oil, or eugenol, peptone, phlorizin, and gum guaiac; 1/3 lb. of clove oil is required per pound of lead; phloridizin is too expensive to be used in industrial work.

An electrolytic process[1] has been patented by J. Matuscheck for the treatment of lead ores in which an aqueous solution of a basic or normal lead nitrate or nitrite in the presence of tannic acid from oak bark forms the electrolyte. The basic salt, $PbNO_3OH.PbNO_2OH$ is obtained by the treatment of a solution of $Pb(NO_3)_2$ for the required time with Pb; when formed, tannic acid is added to the solution with stirring until the evolution of $NO_2$ ceases. With galena as anode and sheet lead as cathode, lead plates of any desired thickness may be obtained; steel wire used as cathode is readily coated with lead. With argentiferous galena, the silver is precipitated in part by the tannic acid as is the sulphur; the precipitation is completed by the addition of a metallic chloride, as for example $PbCl_2$. In the process the sulphide lead ore is enclosed in a bag, the electric contact is made with a carbon rod which, however, does not come in contact with the electrolyte, *i.e.*, the ore has to extend above the electrolyte. A good many practical difficulties would have to be overcome before such a process could be carried out successfully.

[1] German Patent, No. 239222, *Metallurgie*, 1912, IX, 336.

# LITHIA

In the last two years no lithium mineral was produced in the United States. The only deposits that have been worked commercially for the minerals are found in Costa County, S. D., Black Hills district. The minerals here are spodumene, lithiophilite and amblygonite, occurring with pegmatite veins. Another lithia mineral, lepidolite, occurs at Pala Alta, Calif. The industry is on a decline, although some of these properties are ready to furnish the crude minerals. The chemical manufacture from the minerals ought to be stimulated next year as the demand for products is increasing in the United States. The companies in a position to furnish lithium minerals are the Western Reduction Company of Keystone, S. D.; Standard Essence Co., Maywood, N. J., and the Pahasa Mining Company, 16 miles east of Hill City, S. D.; the Caternia Mine, Pala, Calif.

In France, which is the principal source of amblygonite, it is produced at Montrobas. The mineral also occurs in Saxony and in Norway. The import of lithium in the form that it is consumed in the United States is chiefly as carbonate. The consumption in the United States is increasing each year, chiefly on account of the use in the Edison storage battery. It is probable that this use alone consumes in the neighborhood of 50 tons lithium carbonate per year. Another consumer of large quantities of lithium carbonate is the Keasbey & Mattison Company, of Ambler, Pa., which consumption probably exceeds 1 ton per year.

The uses of lithium, chiefly in the form of carbonate, are in storage batteries and for photographic, medicinal and pyrotechnic purposes. In the storage battery it is used in connection with potassic hydrate, but the reaction is not clear, excepting that it is known the effect is beneficial.

# MAGNESITE

In the United States the only production of magnesite in 1912, as in previous years, was from California. A detailed description of these deposits is found in *Bulletin* 355 of the United States Geological Survey. The number of producers in California has dwindled, and the production in 1912 does not appear to have been more than 11,000 tons, as compared with 9000 tons in 1911, and 12,000 tons in 1910. The figures as given by the United States Geological Survey are included in the following table:

STATISTICS OF MAGNESITE IN THE UNITED STATES.
(Tons of 2000 lb.)

| Year. | Production. (a) | | Imports. | | Consumption. | |
|---|---|---|---|---|---|---|
| | Tons. | Value. | Tons. | Value. | Tons. | Value. |
| 1899..... | 1,280 | $18,480 | 20,807 | (e)$174,779 | 22,087 | $193,259 |
| 1900..... | 2,252 | 19,333 | 28,821 | (e) 216,158 | 31,073 | 235,491 |
| 1901..... | 4,726 | 43,057 | 33,461 | (e) 250,958 | 38,187 | 294,015 |
| 1902..... | 2,830 | 20,655 | 49,786 | 373,928 | 52,616 | 394,583 |
| 1903..... | 1,361 | 20,515 | 54,776 | 461,399 | 56,137 | 481,914 |
| 1904..... | 2,850 | 9,298 | 38,704 | 286,828 | 41,554 | 296,126 |
| 1905..... | 3,933 | 16,221 | 74,374 | 638,619 | 78,307 | 654,840 |
| 1906..... | 4,032 | 40,320 | 90,396 | 863,492 | 94,428 | 903,812 |
| 1907..... | 6,405 | 57,720 | 99,008 | 875,359 | 105,413 | 933,079 |
| 1908..... | 8,967 | 52,342 | 84,494 | 736,763 | 93,461 | 789,105 |
| 1909..... | 7,942 | 62,588 | 114,292 | 985,019 | 122,234 | 1,047,607 |
| 1910..... | 8,000 | 59,780 | 170,327 | 1,542,800 | 178,327 | 1,602,580 |
| 1911..... | 9,900 (a) | 67,430 | 134,549 | 1,185,867 | 144,449 | 1,253,297 |
| 1912 ..... | 11,000 | 110,000 | 138,657 | 1,369,665 | 149,657 | 1,479,665 |

(a) Reported by the State Mining Bureau of California. (e) Estimated.

The domestic material is sold ground and calcined, and found a ready sale as a finished product in recent years, at $35 per ton. Business conditions during 1912 in this industry in California were excellent, and the value at the mine of the crude product was somewhat greater in 1912 than the previous year, namely $10 as compared with $8 approximately. During 1910, owing to a severe competition which is reflected by a record production, prices were low. Most of the calcined material is consumed by manufacturers of paper and wood pulp in California and Oregon. A small quantity is used for artificial stone tiling or building material.

Inasmuch as the western magnesite is consumed locally and as its quality for the manufacture of brick and furnace lining has not been

established, the imports of foreign magnesite and the manufacture from this imported material in the eastern districts continue to increase. With further experience and the proper grading of the California product, it is hoped to compete with these products, especially when cheaper freight rates are obtainable on account of the Panama Canal.

The producers in California are the Tulare Mining Company, the California Magnesite Company and the Western Magnesite Development Company.

*Imports.*—The chief source of foreign magnesite is from Hungary and Greece. It is imported into the United States, both crude and calcined in large quantities. The imports for recent years are given in the following table:

IMPORTS OF MAGNESITE INTO THE UNITED STATES.

| | 1910. | | 1911. | | 1912. | |
|---|---|---|---|---|---|---|
| | Pounds. | $ | Pounds. | $ | Pounds. | $ |
| Magnesia: | | | | | | |
| Calcined, medical | 61,471 | 9,519 | 91,029 | 13,694 | 101,106 | 16,326 |
| Carbonate, medical | 46,926 | 2,799 | 50,490 | 2,867 | 60,904 | 2,727 |
| Sulphate | 6,748,388 | 23,565 | 5,950,861 | 22,559 | 10,703,209 | 41,739 |
| Magnesite: | | | | | | |
| Calcined, not purified | 297,652,901 | 1,380,731 | 244,149,581 | 1,109,770 | 241,503,372 | 1,265,339 |
| Crude | 52,002,557 | 162,069 | 25,948,977 | 76,097 | 35,810,752 | 104,326 |

The record importation of both crude and calcined magnesite, that is unpurified magnesite, was in 1910. The import prices averaged in recent years as follows: Crude magnesite per short ton $6.22, $5.78, $5.83; calcined, $9.30, $9.10, $10.20, for the years 1910, 1911 and 1912, respectively.

Newly discovered deposits of magnesite are described by the United States Geological Survey.[1]

A deposit situated three-quarters of a mile northeast of Bissell Station, Kern County, was developed in 1911. This deposit is the only occurrence of sedimentary origin yet found in the United States. Deposits in Quebec are supposed to be sedimentary, but practically all other deposits are residual and derived from altered basic intrusive igneous rocks, carrying a large percentage of magnesia. The Bissell deposit is interbedded with clays and shales. It is not known how extensive the strata may be. A section 7 ft. in thickness is estimated to contain, alternating with the clay beds, three magnesite beds from 10 in. to 1 ft. 6 in. thick. Four analyses of samples are as follows:[2]

[1] Mineral Resources for 1911, p. 1115.
[2] J. G. Fairchild, *Geological Survey*, Washington, D. C.

| | | | | |
|---|---|---|---|---|
| $SiO_2$ | 9.64 | 8.51 | 6.03 | 4.75 |
| $Al_2O_3Fe_2O_3$ | 2.46 | 2.94 | 1.40 | 0.76 |
| CaO | 4.25 | 3.36 | 1.56 | Trace. |
| MgO | 37.19 | 38.32 | 42.78 | 44.20 |
| $CO_2$ | 40.70 | 40.12 | 45.78 | 47.32 |
| Loss and undetermined | 5.76 | 6.75 | 2.45 | 2.97 |

It has been suggested that presence of basic carbonates accounts for the small percentage of carbon dioxide. This particular magnesite is obtained in clean white masses, and readily separates from the inclosing clay. It has a tendency on exposure to the air to break down or slack. It is nevertheless chemically similar to other California magnesites and may prove to contain as little lime.

Prospecting done in Southern San Benito County, about 2 1/2 miles west of the New Idria Quicksilver Mine, disclosed outcrops on the summit between two forks of Larious Creek. Outcrops of the magnesite body cover two to three acres, and are composed of massive blocks of white magnesite. Round nodular magnesite also occurs in weathered or decayed serpentine nearby, and the deposit is derived by the decomposition of this country rock. An anayslis of a piece of tne outcrop is as follows: $SiO_2$, 0.14; $Al_2O_3.Fe_2O_3$, .48; CaO, .59; MgO, 47.07; $CO_2$; 50.66; loss and undetermined, 1.06. This analysis indicates a magnesite of unusual purity.

The deposits of the California Magnesite Company, 4 miles from Winchester, Riverside County, are worked steadily. Some of this magnesite is sintered for furnace use at the company's plant in Los Angeles. The greater part of the output is prepared and used for this purpose or for cement. It is marketed at a comparatively high price. The magnesite occurs as the result of serpentine decomposition, a belt of serpentine traversing the gneisses of the country. An analysis as given by the United States Geological Survey represents a sample of thirty separate portions collected from a network of magnesite veins in one opening: $SiO_2$, 6.17 per cent.; $Al_2O_3-Fe_2O_3$, 0.80 per cent.; CaO, trace; MgO, 43.80 per cent.; $CO_2$ 45.02 per cent.; loss and undetermined, 4.14 per cent.

The material, as ground and shipped by the company, analyses as follows: Insoluble, 14.00 per cent.; iron and alumina, 0.80 per cent.; calcium oxide, 0.61 per cent.; magnesium oxide, 84.59 per cent.

It is estimated that one-tenth of the mass of decomposed rock is magnesite. Experiments for utilizing a crude mixture so as to save much of the magnesite now wasted in serpentine on the dump are being made.

## Magnesite in Foreign Countries

*Austria-Hungary.*—The magnesite is treated at a number of works, among which the factory at Radenthein, Austria, belonging to the Austro-American Magnesite Company, has a capacity of 100 tons per day.

The value of the magnesite exported from Budapest, Hungary, to the United States in 1910 was $808,564, and in 1911, $761,396. The magnesite invoiced through the consulate at Vienna, from Austria-Hungary, and exported to the United States and Philippines, was $1,198,979 in 1910, $683,832 in 1911 and $1,037,543 in 1912. The magnesite exports officially reported in 1911 were 77.4 tons of crude valued 3096 K. and 171,196 tons calcined valued 11,127,740 K. The description of the calcining of magnesite in Austria is given in Mineral Industry, Vol. XX, p. 499.

*Australia.*—Magnesite produced in Victoria in 1911 was from Heathcote, Victoria, and amounted to 166 tons valued at £498.

*Canada.*—The only deposits of magnesite being actively worked at present in Canada are situated in the township of Grenville, a few miles north of the Ottawa River. This deposit is worked by the Canadian Magnesite Company, Ltd., of Montreal. A kiln is now in operation. The kiln is fired with wood, and the product is either stored or goes directly to the pulverizing plant where it is packed for shipment. Some of the crude magnesite is also sold to manufacturers of carbonic acid. The Canadian Carbonate Co. of Montreal is engaged in this manufacture. The Dominion Carbonic Company of Toronto makes $CO_2$ but from coke. The combined output of these firms is estimated in 1912 at 2, 500,000 lb. of liquid gas. In California this gas was formerly obtained as a by-product in treating the crude magnesite for wood pulp. It is claimed that the regularity of this Canadian deposit will allow the development work, by means of bore-holes, to advance rapidly. The deposit is of a sedimentary origin and the magnesite appears much like coarse-grained marble. The composition is as follows:[1] Silica 2 per cent., iron and alumina 1 per cent., lime 9 per cent., magnesia 40 per cent., carbonic acid gas 47 1/2 per cent. water (combination) 0.50 per cent.

It is interesting to note that a considerable market for this material calcined has been established both in Canada and the United States. It is claimed that results are as good as with the Grecian magnesite. Although no exports have yet been made from Canada to Europe, arrangements are being made to supply the European market. The imports of Canada, however, exceed the domestic supply up to the present time. The production of magnesite in Canada during the calendar year 1912 was 1714

[1] Laboratory of Dr. Donald, Montreal.

short tons valued at $9645. The production for 1910 and 1911 was 323 and 991 tons, respectively, the values reported being $2160 and $5531.

*Germany.*—A large industry for the manufacture of magnesium salts is established in Germany. The production of magnesium salts during 1911 amounted to 36,764 tons of chloride, and 55,179 tons of sulphate. The large imports of crude magnesite are notable. During 1911, 47,930 tons of magnesite were imported into Germany. During 1912 the record importation was reached, being 69,064 tons. The export of magnesium chloride in 1912 was 39,080 tons.

*Greece.*—The two principal producers of magnesite in Greece are the Société Anglo Greek de Magnesite operating at Limni and Chalcis, and the Société Hellenique des Mines, operating at Limni, Mantoudi and Pyli. The industry as a whole does not appear to be increasing, but the production of calcined manufactured magnesite increases from year to year. The magnesite exported to the United States from Greece, as declared at Consular offices, was valued at $46,793 in 1910, and $40,873 in 1911.

The sales of magnesite in 1911 were: calcined 24013 metric tons worth $13.44 per ton; dead burnt 3270 tons worth $15.41 per ton; bricks 288 tons worth $41.24 per ton.

*India.*—The production of magnesite from India is falling off in recent years, although requirements of the continental consumers laid down in 1908 at Leipzig are easily fulfilled. These requirements stipulated that impurities be less than 4 per cent. The production of India in 1910 was 5182 long tons, valued at £1382, in 1911, 3490 tons valued at £1047 and in 1912, 15379 tons. A description of the magnesite occurrence in India is given in MINERAL INDUSTRY, Vol. XX, p. 501. The record production occurred in 1908.

*Mexico.*—Margarita Island has a deposit of about thirty acres of magnesite, and a calcining plant is to be installed. The beds are said to contain 92 per cent. of magnesium carbonate. The company which is interested in this deposit has headquarters at San Diego, California, and expects also to work deposits on the Cedros Island.

*Rhodesia.*—A specimen of magnesite from Enkeldoorn district, Southern Rhodesia, was examined recently at the Imperial Institute. It consisted of massive magnesite discolored by layers of brown fibrous serpentine. It gave the following results on analysis:

| | Per cent. |
|---|---|
| Magnesia, MgO | 45.9 |
| Lime, CaO | nil |
| Alumina, $Al_2O_3$ } Ferric oxide, $Fe_2O_3$ } | 0.55 |
| Insoluble matter | 3.04 |
| Loss on ignition | 50.20 |

The above figures indicate the following mineral composition for the ample:

| | Per cent. |
|---|---|
| Magnesite, $MgCO_3$ | 94.4 |
| Serpentine, $3MgO, 2SiO_2, 2H_2O$ | 4.6 |

The material represented by this sample is slightly inferior in purity o the best commercial magnesite, which generally contains from 96 to 8 per cent. of magnesium carbonate and is worth 25s. per ton c.i.f.

The value can be increased by calcining the magnesite before shipnent, as the calcined product is worth 60s. per ton c.i.f.

*Venezuela.*—Deposits of magnesite of good quality were reported arly in 1912, on Margarita Island. The main deposit, which is about mile from the port of Porlamar, in Venezuela, is not considered as a nineral deposit and owners of land or concessions can make free use of he magnesite found. An analysis of the magnesite was MgO 46.34 per ent., equivalent to $MgCO_3$, 96.94 per cent. One American company s reported to be shipping from these deposits, and further explorations re in progress.

THE PRINCIPAL SUPPLIES OF MAGNESITE.
(In metric tons.)

| Year. | Austria-Hungary. (a) | | Greece. (d) | | India. (d) | United States. (d) |
|---|---|---|---|---|---|---|
| | Crude | Calcined | Crude | Calcined | | |
| 899 | ..... | (b) | 17,184 | ..... | (e) | 1,161 |
| 900 | ..... | (b) | 17,277 | ..... | (e) | 2,043 |
| 901 | ..... | 40,236 | 20,348 | ..... | (e) | 4,286 |
| 902 | ..... | 53,467 | 23,020 | ..... | 3,597 | 2,567 |
| 903 | ..... | 69,058 | 28,415 | ..... | 838 | 1,234 |
| 904 | ..... | 53,781 | 9,133 | ..... | 1,193 | 2,585 |
| 905 | ..... | 92,359 | 37,063 | ..... | 2,645 | 3,568 |
| 906 | ..... | 87,765 | 40,584 | ..... | 1,861 | 7,093 |
| 907 | 452 | 113,695 | 55,816 | ..... | 188 | (f) 6,858 |
| 908 | 212 | 87,049 | 63,079 | ..... | 7,655 | (f) 5,994 |
| 909 | 1,027 | 125,666 | 56,797 | 16,609 | 199 | (f) 8,588 |
| 910 | 341 | 182,911 | 18,073 | 19,982 | 5,264 | (f)11,291 |
| 911 | 77 | 171,196 | ..... | 27,283 | 3,546 | (f) 8,505 |

(a) Exports of calcined magnesite. (b) Previous to 1901 magnesite was included with other minerals not elsewhere specified. (d) Crude magnesite. (e) Not reported. (f) U. S. Geol. Surv.

ANALYSES OF MAGNESITE.

| | $SiO_2$ Per cent. | $Al_2O_3$ and $Fe_2O_3$ Per cent. | CaO Per cent. | $CO_2$ Per cent. | MgO Per cent. | $MgCO_3$ Per cent. |
|---|---|---|---|---|---|---|
| Greece | 1 to 2 | 1.75 to 3.20 | 1.10 to 3.20 | ..... | ..... | 92 to 98 |
| Elba | 8.5 | Trace. | 3.50 | ..... | 41 | ..... |
| Transvaal | 2.3 | 0.8 | ..... | 49.8 | 45.3 | ..... |
| New South Wales | 0.42 | 0.54 | *Nil.* | ..... | ..... | 99.01 |
| New Caledonia | 0.8 | 0.8 | 3.3 | 51.5 | 42.4 | ..... |
| Silesia | 5.6 | 0.85 | 0.12 | ..... | ..... | 93.0 |
| Hungary | 0.75 | 3.50 | 1.2 | 50 | 45 | ..... |
| Lower California | Trace. | 0.21 | 0.43 | ..... | ..... | 99.36 |
| Atlin, B. C. | 45.7 | 5.10 | ..... | 27 | 22 | ..... |
| Margarita, Venezuela | 0.2 | 0.15 | 0.56 | 51.6 | 46.93 | 98.04 |
| Magnesium Carbonate | ..... | ..... | ..... | 52.4 | 47.6 | ..... |

The Uses of Magnesite.—The uses of magnesite are enumerated as follows: For furnace linings, refractory brick, crucibles, for cement, for paint, as a binder in briquetting, in sulphite manufacture, for carbonic acid gas, and for pipe coverings and the manufacture of chemical compounds, for toilet and medicinal purposes. The magnesite in California is used principally in the manufacture of paper. The material from Porterville and all the California deposits, excepting the one at Winchester, is at present used for paper pulp manufacture. Only a small percentage of the products at Winchester is used for furnaces; probably no more than 10 per cent. In the Eastern States, the manufacture of magnesium carbonate is carried on by a number of firms, among them the Keasbey & Mattison Company, Ambler, Pa., produce at least 6000 of the manufactured article per year. Among the manufacturers of refractories, the imported article is made into brick and also sold as calcined magnesite suitable for hearths. The Harbison & Walker Company, Pittsburg, Pa., probably produce more than 50,000 tons of manufactured magnesite per year. Another firm which handles large quantities is the American Refractories Company, Chicago, Ill. The product comes directly from the Austrian works of this company. An increase in the use of magnesite brick makes it probable that the world's consumption of such brick exceeded 110,000 tons.

The use of magnesite brick for furnace linings is being tried in a number of cases where basic lining is required, in addition to copper converters and basic open hearth steel furnaces. The first cost is high, but repair charges are correspondingly low. Care must be taken to keep the magnesite from silica, and mixtures of ground magnesite with either linseed oil or with sodium silicate are recommended. Where it is necessary to use silica brick lining with magnesite, they are best separated by a course of chrome brick. Expansion of 1/4 in. per foot may be allowed. A difficulty with the magnesite brick is the scaling of the brick. This can be prevented by avoiding the sudden changes in temperature and avoiding moisture when the brick is laid. The resistance of the magnesite brick to fluxing action is excellent if properly laid.

*Lining Converters.*—The use of magnesite brick in the practice at Anaconda is as follows: The brick are laid with a sodium-silicate mortar on a 1-in. bed of peagrain magnesite, to allow for expansion. At the tuyères, in place of the brick, a belt is tamped about 8 to 10 in. high and 14 in. thick, consisting of a mixture of 80 per cent. magnesite dust and 20 per cent. of a 40 per cent. sodium-silicate solution; in half an hour it is set fairly well, and at the end of a few hours this part of the lining is said to be practically as hard as the brick portion.

The calcining of a magnesite having the composition 94.11 per cent.

$MgCO_3$, 0.50 per cent. $CaCO_3$, 0.84 per cent. $FeCO_3$, 1.40 per. cent. $SiO_2$ was performed in the laboratory.[1] The results show that at 750° C. the loss of weight amounts to 96.8 per cent. of the theoretical; at 950°, 98.4 per cent. Decomposition begins at 570°.

Magnesia tubes, crucibles, etc., are made by the process of George Weintraub of the General Electric Company. (U. S. patent 1022011, April 2, 1912.) The product is smooth and strong and no binder is used.

According to the Book of Standards of the National Tube Company, the following insulating properties and data in regard to the insulation of steam pipes is given for magnesia:

| | Size of pipe, inches. | Thickness of covering, inches. | Loss in b.t.u. per sq. ft. per hour per degree difference of temperature. | Percentage of heat lost, bare pipe loss at 100. | Authority. |
|---|---|---|---|---|---|
| (g) Magnesia | 2 | 2.41 | 0.302 | 11.2 | Stott. |
| (h) Magnesia | 10 | 1.37 | 0.354 | 13.1 | Barrus. |
| Magnesia | 8 | 1.25 | 0.384 | 14.2 | Brill. |
| (e) Magnesia | 2 | 1.16 | 0.439 | 16.3 | Stott. |
| (f) Magnesia | 4 | 1.12 | 0.465 | 17.2 | Norton. |
| Magnesia | 2 | 1.08 | 0.304 | 11.3 | Jacobus. |
| (h) Magnesia | 2 | 1.08 | 0.531 | 19.7 | Barrus. |

(g) Carbonate of magnesia, 85 per cent. Average of a number of tests of molded sectionals, thickness of covering ranging from 2.20 to 2.71 in.
(h) Carbonate of magnesia with some asbestos fiber; outside finished with canvas.
(e) Average of tests, thickness of covering ranging from 1.12 to 1.19 in.
(f) Molded sectional covering composed of about 90 per cent. carbonate of magnesia.

*Magnesite Floorings.*—It is stated that in Germany flooring for public and office buildings is being made from a mixture of magnesia and sawdust, wet with magnesium-chloride solution.[2] The mixtures are not patented, but the manufacturers keep them secret.

Whereas the magnesia flooring was first used as a base for linoleum, it has been found possible to give the mixture a good color, and a fine marble-like finish, in which case it costs about $1.34 per square meter. It is stated to be crack-free, warm under foot, elastic, and sound- and water-proof.

*Metallic Magnesium and Calcium.*—During the calendar year 1912 it is reported by prominent manufacturers, such as The Virginia Electrolytic Company, that there are no new developments in the magnesium and calcium production. The works of this company are at Holcomb's Rock, Va.

The processes for manufacturing magnesium and calcium have been perfected by the Virginia Electrolytic Company so as to be

[1] K. Fredrick and Garrett Smith, *Metallurgie*, Heft. 13, IX, 1912, July 8, p. 414.
[2] *Daily Cons. and Trade Reports*, Aug. 7, 1911; Apr. 17, 1912.

commercially available, but the market for these metals does not appear to expand rapidly and very little interest is taken in the production. Much research work on light alloys of magnesium and also those of calcium is on record. Research work in regard to the use of calcium as a purifying agent is also extensive, but it has not progressed beyond the experimental stage.

The efforts of the manufacturers during the year were to introduce these metals and the same will be true probably for the greater part of 1913.

A review of the metallurgy of magnesium and other metals is given in the *Mem. d. l.'Soc. Ing. Civ. de France*, Oct., 1911.

Resistivity of magnesium was determined by E. F. Northrup, Palmer Physical laboratory, Princeton, N. J.[1]

*Calcium.*—Casting magnesium alloys to avoid the effects of oxidation by adding small quantities of calcium has been patented by Berthold Hoffman and Robert Suchy, Grieshein, Germany. 0.1 per cent. to 5 per cent. Ca prevents burning, efflorescence and the dark skin forming on the metal.[2] The property given by the Ca is said to be retained after repeated meltings.

Most of the methods for producing pure calcium have been by the electrolysis of the chloride, together with fluoride. Various efficiencies are claimed[3] up to 80 per cent. Frary and Badger in the University of Minnesota laboratory obtained 46 per cent. under unfavorable conditions. The work was continued with the same apparatus which consists of a large anode crucible of Acheson graphite having a water-cooled bottom and a water-cooled iron cathode 1 in. in diameter. The crucible was enclosed in a protective layer of refractory material. Intermittent addition of electrolyte was one of the causes of low efficiency. When metal was deposited in the spongy form it was generally lost by convection currents of the liquid. Spongy metal also resulted when the stick of metal extended too far below the surface of the melt, the current density being insufficient to melt the metal at the point of contact with the electrolyte. If kept just in the liquid the spongy metal fuses and solidifies at once, forming a solid stick.

The use of fluoride in order to obtain a low melting-point was not found to have any advantage and did not produce solid metal, as its requisite fusion was not possible. Much of the fluoride is lost during the process, probably due to spattering.

[1] *Met. and Chem. Eng.*, Vol. X, p. 277.
[2] U. S. patent 1028216 June 4, 1912.
[3] F. C. Frary, N. R. Bickwell, C. A. Tronson, *Am. Electro.-chem. Soc.*, 1911.

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### Magnesite

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### Magnesium

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[illegible]

[illegible]

[illegible]

d States of manganese ore, were 212,755 long tons in 1909, 242,348
1 1910, 176,852 tons in 1911, and 300,661 tons in 1912. The import
; per ton, were respectively $6.62, $9.68, $6.72, and $5.88 per ton.
re is imported free of duty. The production of various States is
iven in the table. The production is chiefly from Virginia, and the
ge prices per ton of the high-grade ore ranged between $12.74 in
$10.14 in 1910, $10 in 1911 and $9.45 in 1912.

ie prices are governed according to the grade, and are based on ores
ining not more than 8 per cent. silica or 0.2 per cent. phosphorus,
t to deductions for each 1 per cent. in excess of the 8 per cent. silica
cents and a deduction of 2 cents per unit of manganese per ton for
).02 per cent. or fraction, in excess of 0.2 per cent. phosphorus.
Carnegie Steel Company in 1910 established a scale of prices for
livered at Pittsburgh, Bessemer, or South Chicago. The price per
f manganese was 26 cents over 49 per cent., 25 cents from 46 to
cent., 24 cents from 43 to 46 per cent., and 23 cents from 40 to 43
nt. Iron was paid for at 5 cents per unit. The imports and
mption of manganese ore in the United States is given in the follow-
ble:

UNITED STATES IMPORTS AND CONSUMPTION
(Tons of 2240 lb.)

| Year. | Imports. | | Consumption. | | Production of Manganese-Silver Ores. (*b*) | |
|---|---|---|---|---|---|---|
| | Long Tons. | Value. | Long Tons. | Value. | Long Tons. | Value. |
| ..... | 188,349 | $1,584,528 | 331,605 | $ 1,891,004 | 79,855 | $266,343 |
| ..... | 256,252 | 2,042,361 | 473,798 | 3,214,808 | 188,509 | 897,068 |
| ..... | 165,722 | 1,486,573 | 804,568 | 3,130,690 | 228,187 | 865,959 |
| ..... | 235,576 | 1,931,282 | 1,209,513 | 4,077,065 | 174,132 | 908,098 |
| ..... | 146,056 | 1,278,108 | 806,638 | 2,948,457 | 179,205 | 649,727 |
| ..... | 108,519 | 901,592 | 563,100 | 1,690,724 | 105,278 | 348,132 |
| ..... | 257,033 | 1,952,407 | 1,120,696 | 3,633,879 | 127,170 | 445,095 |
| ..... | 221,260 | 1,696,043 | 1,362,941 | 5,100,036 | 163,760 | 573,160 |
| ..... | 209,021 | 1,793,143 | 1,531,882 | 5,653,408 | 103,844 | 259,473 |
| ..... | 178,203 | 1,350,223 | 825,353 | 2,644,523 | 51,554 | 123,407 |
| ..... | 212,765 | 1,405,329 | 1,199,246 | 3,920,592 | 65,024 | 209,495 |
| ..... | 242,348 | 1,711,131 | 880,248 | 3,573,112 | 55,770 | 176,448 |
| ..... | 176,852 | 1,186,791 | 769,209 | 2,464,000 | 41,753 | 109,340 |
| ..... ..... | 300,661 | 1,769,184 | 1,227,000 | 3,738,900 | 48,618 | (*d*) 12,646 |

lined in Colorado and used as flux in silver-lead smelting; not included in the statistics of con-
. The statistics of manganiferous silver ore for 1908–10 are as reported by the U. S. Geological
(*d*) Not including precious metals.

e largest quantities of manganese ore are imported from India into
nited States. The imports from Brazil are second, and those from
third. In 1911, the imports were as follows: British India,
0 long tons valued $4.71 per ton; Brazil, 41,600 tons valued $8.21
n; Russia, 19,103 tons valued $9.81 per ton; France, 4043 tons

valued $12.77 per ton; Germany, 3941 tons valued $19.52 per ton. The ore is divided uniformly between Philadelphia and Baltimore, with a small quantity to New York.

The steel industry in the United States produces its own manganese alloys excepting imports of ferro-manganese as shown in the following table:

UNITED STATES PRODUCTION AND IMPORTS OF IRON-MANGANESE ALLOYS.
(Tons of 2240 lb.)

| | 1909 | | 1910 | | 1911 | | 1912 | |
|---|---|---|---|---|---|---|---|---|
| | Production | Imports | Production | Imports | Production | Imports | Production | Imports |
| Ferromanganese... | 82,209 | 88,934 | 71,376 | 114,227 | 74,482 | 80,263 | 127,939 | 99,127 |
| Spiegeleisen..... | 142,831 | 16,921 | 153,055 | 25,383 | 110,235 | 20,971 | 100,000 | 1,015 |
| Totals..... | 225,040 | 105,855 | 224,431 | 139,610 | 184,717 | 101,234 | (a)227,939 | 100,152 |

(a) Sales.

Ferro-manganese is imported from England, the value in 1911 being $1,082,000. Silico spiegel was also imported from England valued at $4161 in 1911, and $12,184 in 1910.

*Notes on Foreign Countries.*—It is not likely that foreign deposits can be more favorably situated than those of India and those of Russia. The transportation for these deposits is ideal for cheap delivery of the ore to foreign countries. The production of the principal countries in the world is shown in the following table:

WORLD'S PRODUCTION OF MANGANESE ORE. (a)
(In metric tons.)

| Year. | Austria-Hungary. | Belgium. | Bosnia (b) | Brazil (d) | Canada. | Chile. (d) | Colombia. | Cuba. | France | Germany. | Greece. | India. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1899 | 10,484 | ..... | 5,270 | 65,000 | 279 | 40,931 | 10,160 | ..... | 39,897 | 61,329 | 17,600 | 88,520 |
| 1900 | 14,550 | 10,820 | 7,939 | 108,244 | 34 | 25,715 | 8,748 | 21,973 | 28,992 | 59,204 | 8,050 | 129,865 |
| 1901 | 12,077 | 8,510 | 6,346 | 100,414 | 447 | 18,480 | 95 | 25,586 | 22,304 | 56,691 | 14,166 | 122,831 |
| 1902 | 12,883 | 14,440 | 5,760 | 157,295 | 175 | 12,990 | *Nil.* | 40,048 | 12,536 | 49,812 | 14,960 | 160,311 |
| 1903 | 11,489 | 6,100 | 4,537 | 161,926 | 135 | 17,110 | (c) | 21,070 | 1,583 | 47,994 | 9,340 | 174,363 |
| 1904 | 15,460 | 485 | 1,114 | 208,260 | 123 | 2,324 | (c) | 33,152 | 11,254 | 52,886 | 8,549 | 152,601 |
| 1905 | 23,732 | *Nil.* | 4,129 | 224,377 | 22 | 1,323 | (c) | (d) 8,096 | 6,751 | 51,463 | 8,171 | 250,788 |
| 1906 | 20,577 | 120 | 7,651 | 121,331 | 84 | 35 | (c) | (d) 13,997 | 11,189 | 52,485 | (d) 9,200 | 579,231 |
| 1907 | 24,954 | 2,100 | 7,000 | 236,778 | 1 | (c) | (c) | 30,486 | 18,200 | 74,683 | 10,000 | 916,770 |
| 1908 | 27,257 | 7,130 | 6,000 | 166,122 | *Nil.* | 1 | (c) | 1,492 | 15,865 | 67,692 | 10,750 | 685,135 |
| 1909 | 29,966 | 6,270 | 5,000 | 240,774 | *Nil.* | (c) | (c) | 2,976 | 9,378 | 77,177 | 5,374 | 652,958 |
| 1910 | 28,964 | *Nil.* | 4,000 | 253,953 | *Nil.* | (c) | (c) | (c) | 7,925 | 80,559 | 41 | 813,761 |
| 1911 | 15,954 | *Nil.* | 3,600 | 213,000 | *Nil.* | (c) | (c) | ..... | 6,000 | 87,297 | 733 | 679,848 |
| 1912 | ..... | ..... | 4,650 | 154,870 | *Nil.* | (c) | (c) | ..... | ..... | ..... | ..... | 648,000 |

| Year. | Italy. | Japan. | New. Zealand. | Portugal. | Queensland. | Russia. | Spain. | Sweden. | United Kingdom | United States. (e) |
|---|---|---|---|---|---|---|---|---|---|---|
| 899.. | 4,356 | 11,336 | 137 | 2,049 | 747 | 659,302 | 104,974 | 2,622 | 422 | 145,548 |
| 900.. | 6,014 | 15,831 | 166 | 1,971 | 77 | 802,236 | 112,897 | 2,651 | 1,384 | 221,714 |
| 901.. | 2,181 | 16,270 | 208 | 904 | 221 | 522,395 | 60,325 | 2,271 | 1,673 | 649,016 |
| 902.. | 2,477 | 10,844 | *Nil.* | (c) | 4,674 | 536,519 | 46,069 | 2,850 | 1,299 | 989,519 |
| 903.. | 1,930 | 5,616 | 71 | 30 | 1,341 | 414,334 | 26,194 | 2,244 | 831 | 671,151 |
| 904.. | 2,836 | 4,324 | 199 | (c) | 843 | 430,090 | 18,732 | 2,297 | 8,880 | 461,854 |
| 905.. | 5,384 | 14,017 | 55 | (c) | 1,541 | 508,635 | 26,020 | 1,992 | 14,582 | 877,482 |
| 906.. | 3,060 | 54,339 | 16 | 22 | 1,131 | 1,015,686 | 62,822 | 2,680 | 23,126 | 1,141,681 |
| 907.. | 3,654 | 20,589 | 26 | 1,374 | 1,134 | 995,282 | 41,504 | 4,334 | 16,356 | 517,177 |
| 908.. | 2,750 | 11,130 | *Nil.* | (c) | 1,403 | 362,303 | 16,945 | 4,616 | 6,409 | 633,650 |
| 909.. | 4,700 | 8,708 | 6 | (c) | 613 | 574,938 | 7,827 | 5,212 | 2,812 | 986,477 |
| 910.. | 4,200 | 11,120 | 5 | (c) | 805 | (d)668,050 | 8,607 | 5,752 | 5,554 | 784,464 |
| 911.. | 3,515 | 9,769 | 1 | (c) | 1,000 | (d)584,000 | 5,607 | 5,377 | 5,057 | 644,288 |
| 912 . | 2,641 | (c) | ..... | (c) | 311 | (d)766,000 | ..... | 5,101 | 4,170 | 990,000 |

(a) From official statistics. (b) Includes Herzegovina. (c) Statistics not available. (d) Export returns. (e) Includes output of manganiferous iron ore. (f) Six months.

*Brazil.*—All the manganese ore is exported and some of the deposits have been worked since 1894. The principal mine is said to produce about 60,000 tons of ore per year. This mine is in the State of Minas Geraes, but important deposits are worked in the States of Bahia and Mattogrosso. The freight rates and the possibilities of competition with India ores are enumerated in MINERAL INDUSTRY, Vol. XX, p. 508. The following table gives the exports of manganese ore from Brazil in the years 1910, 1911 and 1912:

| | 1910. | | 1911. | | 1912. | |
|---|---|---|---|---|---|---|
| | Metric tons. | Dollars. | Tons. | Dollars. | Tons. | Dollars. |
| Manganese ore | 253,953 | 1,887,747 | 173,941 | 1,254,061 | 154,870 | 1,115,079 |
| United States | 59,350 | 435,905 | 50,150 | 361,085 | 82,530 | 594,224 |
| Great Britain | 55,200 | 405,445 | 41,801 | 301,617 | 25,300 | 182,163 |
| Belgium | 29,000 | 207,114 | 34,840 | 250,851 | 10,900 | 78,481 |
| Germany | ..... | ..... | 14,100 | 101,849 | 20,000 | 144,002 |
| France | ..... | ..... | 7,650 | 55,442 | 10,340 | 74,449 |

The output of manganese ore has not increased owing to a decline in the demand of the United States and Europe. Ore cannot be landed in Europe for less than $15 per ton.

The Brazilian ore averages 50 to 53 per cent. manganese, 3 to 3.5 per cent. iron and 0.03 per cent. phosphorus.

In Uruguay the deposit near Tacuarambo (Pampa station) is to be connected by a railroad with Cerro Paraguay, thus giving an outlet for this ore. The line will be constructed by the State and leased to the Central Railway at $739 per kilometer per year for 15 years.

*India.*—The amount of manganese ore shipped from India appears to be the same as in 1911. According to Consul Edward J. Norton,

272,795 long tons were exported from Bombay during 7 months, ending October, 1912. The value of this ore was $1,430,539. Of this, shipments to the United States amounted to 70,800 tons valued at $344,831. All the shipments are from the port of Bombay. The value of the manganese ore exported to the United States from Madras presidency, during the last quarter of 1912, was valued at $51,812, only small lots were exported the first part of the year. The manganese industry of India was described in records of the Geological Survey of India, Vol. XXXIX. The production in India is given in the following table:

PRODUCTION OF MANGANESE ORE IN INDIA. (a)
(In tons of 2240 lb.)

| State. | 1906 | 1907 | 1908 | 1909 | 1910 | 1911 |
|---|---|---|---|---|---|---|
| Baluchistan | ..... | 15 | ..... | ..... | ..... | ..... |
| Bengal | 1,000 | 2,933 | 20,000 | 55,060 | 41,958 | 25,152 |
| Bombay | 7,520 | 22,821 | 23,232 | 17,657 | 30,921 | 45,330 |
| Central India | 50,073 | 35,743 | 13,315 | 10,324 | 12,664 | 7,319 |
| Central Provinces | 351,880 | 565,017 | 431,055 | 381,285 | 552,239 | 445,051 |
| Madras | 114,710 | 162,455 | 118,089 | 138,454 | 120,607 | 125,865 |
| Mysore | 46,312 | 113,307 | 68,624 | 39,895 | 42,518 | 21,573 |
| Totals | 571,495 | 902,291 | 674,315 | 642,675 | 800,907 | 670,290 |

(a) From *Records* of the Geological Survey of India.

Both output and production have in recent years fallen off, chiefly owing to low prices. These averaged in 1910 9.5 and 0.3d. per unit per ton of first and second grade ores, and in 1911, 9.3 and 9d. respectively. It is impossible to compare the state of the industry in different years, as stocks may have accumulated when the output was high but usually of a lower price at Indian ports. Shipments in 1910 amounted to 553,628 long tons against 586,577 tons in 1911. No manganese ore is consumed in India, all of it being exported. The value of the 1910 production averages $5.15 per ton and the 1911 production $4.71 per ton.

"Manganese Mining in British India,"[1] reviews the history of the industry, describing the ore deposits, occurrence, etc.

*Russia.*[2]—Manganese ore is produced in three parts of Russia. The Caucasus (Chiaturi), South Russia (Nikopol), and in the Urals. On account of its geographical position, the last is only of local importance, as all its ore goes to the metallurgical works. The Chiaturi ores go to the South Russian iron works, to the extent of 10 per cent. of the production, whereas 90 per cent. is exported. The Nikopol ores, however, are used to a much larger extent, namely, 80 per cent. in the local iron works and 20 per cent. being ezported. The export of Chiaturi ores in 1912

[1] Herbert A. Carter, *Min. and Sci. Press*, Dec. 30, 1911.
[2] Abstract from article by Ede Hautpick, *I. R. E., Min. Journ.*, Jan. 4, 1913, p. 3.

is estimated at 754,000 tons against 574,535 tons in 1911, 637,718 tons in 1910, and 524,249 tons in 1909. The exportation of 1912 is the highest on record. In 1912 Russian ores were exported to the United States to a greater extent than in the 4 preceding years. In recent years the United States has replaced the Russian ores more or less with those from Brazil. Up to about 1900, England was the largest importer of Russian ores, but now Brazilian and East Indian ores are preferred. The following table shows the export in tons of Russian manganese ores to various countries in the last 5 years:

| Year. | Germany. | England. | Belgium. | France. |
|---|---|---|---|---|
| 1907 | 233,900 | 171,600 | 6,800 | 24,600 |
| 1908 | 173,500 | 111,710 | 54,900 | 29,000 |
| 1909 | 286,610 | 142,300 | 65,000 | 19,500 |
| 1910 | 285,450 | 138,000 | 88,650 | 38,000 |
| 1911 | 291,100 | 124,000 | 64,900 | 41,400 |

It will be noted that Germany is the largest consumer, and that this tendency continued in 1912. The ores from the Caucasus reached Germany via Dutch ports. The exports to Germany from South Russia by rail have declined considerably. In 1907 such exports were 83,600 tons, and in 1912 only 36,000 tons. The demand on the part of the Russian metallurgical works is responsible for this.

The manganese deposits of Chiaturi extend over an area of 500 square miles, which is tributary to the river Kvirila and its branches which cut deep ravines in the territory, exposing the deposits. These vary from 5 to 7 ft. in thickness, and contain up to 11 layers of ore 5 in. thick. The average contents is 85 to 90 per cent. oxide, namely, pyrolusite. The beds lie horizontally. In addition to these high-grade deposits, low-grade ones are found nearer the Black Sea, in the government of Kutais.

The Nikopol ore deposits appear to be local accumulations of manganese, concentrated by the action of surface water in the sand and clay beds. They are of inferior quality and are important only on account of their geographical position.

The prices of Chiaturi manganese were higher in 1912 than in 1911, namely 5 1/2 to 6 copecks per pood, against 4.5 to 5.3 copecks. The price therefore remains about 1 1/2 d. per unit, f.o.r. Chiaturi (in 1907 the price was 6 to 7d.). The Chiaturi manganese is all exported by sea through Poti and Batoum. The larger quantity, namely, 66 per cent. of the total, being exported through Poti.

The Ural, where manganese is produced in the government of Perm and in the government of Orenburg, has a small production. The an-

nual production before 1908 was about 4200 tons. In 1909 and 1910 no production occurred, but again in 1911 2200 tons were extracted. The revival in 1912 caused a production of about 4200 tons.

The total production of manganese in Russia in 1912 is about 1,000,000 tons. As far as small miners are concerned, the situation does not improve as they have to produce ore in order not to die of starvation.

The following table shows the approximate exports from the ports of Poti and Batoum during the last 5 years:

| Ports. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|
| Poti | 366,600 | 544,000 | 364,500 | 442,460 | 618,245 |
| Batum | 8,160 | 28,238 | 43,119 | 129,233 | 309,000 |
| Total | 374,760 | 572,238 | 407,619 | 571,693 | 927,245 |

Manganese ore exported over Caucasus, European, Black Sea and Finland frontiers was valued $3,760,865 in 1910, and $3,424,750 in 1911. Of this in 1911 to Germany $460,410, to Netherlands $1,446,635, to United Kingdom $869,835. The manganiferous iron ore declared at American consulates and exported to the United States was $301,602 in 1910, $197,737 in 1911, and $521,791 in 1912. This includes European Russia and Western Siberia.[1]

The manganese-ore industry[2] of the Caucasus experienced somewhat of a check in 1911 because of the high rates for freights caused by the seamen's strikes in England and the Turko-Italian war. Exporters found it difficult to meet their engagements and by the end of the year deliveries were much in arrears. Under these conditions the quantity of manganese sent away from the Tchiatouri mines was 629,516 tons, a decrease of 8065 tons from 1910. The production of the ore at the mines in 1911 was estimated at about 548,387 tons.

An important feature in the ore trade of Batum for 1911 was the amount of exports diverted from Poti to Batum, causing an increase in exports from 43,119 tons in 1910 to 129,233 tons in 1911. This was brought about by the imposition at Poti of a tax of 1/2 kopeck per pood (0.25 cents per 36.11 lb.) to pay for a mechanical loading device recently installed at that port. The exporters of washed ore in consequence diverted their shipments to Batum. The year 1912 had an export of manganese ore surpassing that of any previous year. The year opened with the entrance into the field of companies controlling large amounts of capital. One German company has obtained control

[1] *Dly. Consls. and Tr. Rep.*, Sept. 25, 1912; March 15, 1913.
[2] C. F. W. Cauldwell, Batum, *Dly. Consls. and Tr. Rep.*, Dec. 9, 1912.

of mines at Tchiatouri (the center of the industry) and has spent considerable money installing washing plants and mechanical means for handling the ore from the mines to the railway. This company has assumed contracts to furnish during the year at least 100,000 tons, and if possible 150,000 tons of ore, practically all of which will go to Germany. It is understood that a portion of this contract includes shipments destined for the United States. To fill this contract an average of one steamer load must be dispatched from Batum each week during the 12 months.

The ore exported from these ports in 1911 went to the following countries:

| Exported to— | From Poti 1911. | From Batum 1911. | From Batum 1912. | Exported to— | From Poti 1911. | From Batum 1911. | From Batum 1912. |
|---|---|---|---|---|---|---|---|
| | *Tons.* | *Tons.* | *Tons.* | | *Tons.* | *Tons.* | *Tons.* |
| Austria | 8,928 | 4,256 | 10,246 | Spain | 30,390 | ..... | ..... |
| Belgium | 53,315 | 12,994 | 37,965 | United Kingdom | 105,943 | 31,869 | 28,443 |
| France | 29,925 | 15,885 | 20,137 | United States (direct) | 5,450 | 10,694 | 56,880 |
| Germany | 4,345 | 25,536 | 44,325 | | | | |
| Netherlands | 204,164 | 27,999 | 79,503 | Total | 442,460 | 129,233 | 277,499 |

Much of the ore shipped to European countries is eventually transshipped and finds its way to the United States. An average of three full shiploads of the ore is sent each year from Batum and Poti to the United States in chartered vessels.

The ore exported through the ports of Batum and Poti generally contains 48 to 52 per cent. of manganese metal, while the peroxides of manganese shipped, which are obtained from washing the granular ore and are used for chemical purposes (glass making), contain 81 to 90 per cent. of peroxide of manganese.

Early in 1913 the price of Russian manganese ore increased practically one-third. Fifty per cent. quality rose to 10d. c.i.f. United Kingdom ports. At the mines the price rose to 2d. per unit f.o.r. The average price during the last 3 years has been as low as 1 1/2d per unit of 1 per cent.[1]

The committee of manganese producers in the Sharopan district in the Kutais government has requested permission to call a congress of manganese producers to discuss statistics and conditions of production—exports, stocks, transportation, etc.

*Other Countries.*—In Austria-Hungary the value of 15,954 tons produced in 1911 was 174,872 crowns. Of this 14,755 tons was produced in Hungary. The imports were 62,082 tons in 1912, valued

[1] *Min. Journ.*, May 17, 1913.

2,373,317 crowns. Bosnia produced 4650 tons valued 102,300 crowns. France produced 6000 tons of ore in 1911; the exports were 2282 tons. The imports were 235,400 tons in 1911, 225,400 tons in 1912, and 188,200 tons in 1910. The imports of manganese ore into France through the port of Dunkirk were valued at $92,641 in 1910, and $112,571 in 1911. Germany produced 87,297 tons of manganese ore in 1911. The imports were 487,872 tons, 420,709 tons and 523,125 tons in 1910, 1911 and 1912, respectively, and the exports 4557, 9615 and 7117 tons in these years. The value of the exports of manganese ore from Erfurt, Germany, to the United States were $23,892 in 1910, and $16,417 in 1911. The production of manganese ore in Japan is given in the table at the end of this volume. In 1910, 11,299 metric tons were produced. The figure for 1911 was 9769 tons. The production of Spain in 1911 was 5607 tons valued at 31,750 pesetas at the mine. The exports for the years 1911 and 1912 compare as follows: 26,602 tons in the former year and 29,764 tons in the latter. The exports from the Huelva, Spain,[1] include carbonate of manganese—in 1911, 26,455 short tons; in 1912, 30,095 tons. In Australia one mine in Queensland produced its regular quota, and in Victoria 2 tons of ore were extracted in the year 1911. Manganese ore is found in Bulgaria. At the Bela property 7 1/2 miles south of the post of Varna thin layers of wad occur in clay. At the Dobra Nadejda, 2 miles from the station of Jambouli, pyrolusite beds 1 to 4 ft. thick have a limestone hanging and andesite foot. The ore is low grade. The last official report of the Department of Mines and Forests of Turkey is for the fiscal year ending March, 1909: In 1908, 14,349 metric tons manganese ore were produced valued at £19,617; 1909, 7,578 metric tons valued at £10,000. In the *Bulletin de la Societe d'Encouragement*, Mr. Polie states that important manganese deposits exist in Sinai promontory, Egypt, and these could compete with the Caucasian ores if a railway 90 miles long were constructed.

In the United Kingdom the bulk of manganese ore worked in North Wales is ferruginous, obtained from Ordovician shales, the contents being 30 per cent. manganese and 10 per cent. iron. The ore from Merionethshire is rhodonite occurring in beds in the Lower Cambrian. In 1911 the value of 4987 tons of manganese ore at the mines was £3997. The output of manganese ore reached its highest mark in 1906 when 22,760 tons were produced.

The imports of manganese ore in 1911 were proportioned as follows:

From Russia 157,331 tons, from British East Indies 217,664 tons, from Brasil 80,068 tons—total 482,209 tons. Foreign and colonial exports of manganese ore to the United States were valued at $19,154 in 1910,

[1] *Dig. Consular and Tr. Rep.*, July 2, 1913.

and $18,531 in 1911. Other exports are in the form of ferromanganese, of which from Hartlepool to the United States the exports were in 1910, $12,184, and in 1911, $4161. The exports of silico spiegel from the same port were valued at $12,184 in 1910 and $4161 in 1911. In addition, spiegeleisen was exported valued $137,895 in 1910 and $168,063 in 1911.

## Technology

*Extraction from Siliceous Ores.*—Siliceous manganese and iron ores may be treated according to the method of N. Farugi, Italy.[1] A product containing any proportion of iron, manganese, calcium or magnesium is obtained, free from phosphorus and sulphur, and one that is briquetted easily. The process consists in dissolving the iron manganese, etc., by HCl generated by steam under pressure and magnesium chloride. The filtered solution is precipitated by the MgO obtained in making the HCl. By replacing this in part by lime, the manganese is precipitated as $Mn_3O_4$. The $CaCl_2$ is treated with MgO and $CO_2$, thus regenerating $MgCl_2$ and precipitating $CaCO_3$ which can be calcined.

*Manganese Steel.*—Manganese steel came into prominence 20 years ago. The properties are extreme hardness with toughness and malleability. The metal connot be commercially cut or drilled. The treatment of this steel to avoid brittleness requires quenching at the proper temperature; if allowed to cool slowly it becomes brittle. The use in steel castings for crusher parts, gears, etc., is now standardized.

*Mangano-silicon.*—Mangano-silicon is now manufactured from rhodonite.[2] Three thousand kilograms of rhodonite are heated with 500 kg. of coke. Ninety kilograms of electrodes are consumed in the process, and 5400 kw.-hours of electric energy are required per metric ton of mangano-silicon produced. The slag, it is said, can be employed for the production of a 50 per cent. ferrosilicon containing some manganese.

*Manganese Bronze.*—Although the percentage of manganese used in this alloy is insignificant, the basis of preparation is a ferromanganese. The nature of the product and history are given in a special article in this volume.

This metal is probably the most moderate priced of the non-ferrous alloys and its use on account of strength and other properties is extending.[3] The high shrinkage of manganese bronze requires more than usual care in the design of a test coupon and the alloy is condemned in many cases owing to the coupon not being properly designed. Chilled coupons

[1] *Chemiker Zeitung*, April 26, 1913.
[2] *l'Echo des Mines*, Nov. 21, 1912.
[3] Wm. M. Corse and V. Skillman, "Manganese Bronze Tests," *Eighth Int'l. Cong. Appl. Chemistry.*

though of 5 to 10 per cent. higher tensile strength than sand cast ones can be used if the fact is taken into consideration. The patterns as suggested by various members of the Am. Soc. for Testing Materials are found most satisfactory. These consist of blocks 3 in. wide, 4 in. high, 4 1/2 in. long with 1-in. square coupon extending lengthwise along each side at the bottom and along the center, making three sets. The high elastic limits usually credited to manganese bronze result from the personal error in reading the elastic limit.

*In Glass.*—The use of manganese in the manufacture of glass is being largely abandoned because where glass is exposed to sunlight, chemical changes are produced which change the color.

*Fertilizer.*—It is proposed to make further experiments with manganese salts as fertilizers.[1] The sulphate would appear to be the most effective and the binoxide the least. Probably good results with the sulphate could be obtained with less than 75 lb. per acre. The exact effect would have to be tried on a large scale in varying soils and under different climates. Manganese sulphate can be bought for about $75 per ton, according to English quotations. The ultimate effects of these salts are not definitely determined.

*Manganese Determination.*—William Blum[2] describes the bismuthate method. The accuracy of this method is satisfactory for high-grade products, where the many other methods used by different chemists did not agree.

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[1] M. X. Sullivan and W. O. Robinson, Bureau of Soils, "Manganese as a Fertilizer," *The American Fertilizer Bulletin*, Feb. 15, 1913.

[2] *Eighth Int'l. Congress Appl'd. Chemistry.*

# MICA

The United States produced a steady output of mica, as shown by the values of the total product in recent years. In 1912[1] the value was $331,896; this was largely in rough trimmed or cut mica, although the production of scrap mica continues to be about one-seventh the total value. A maximum total production of mica occurred in 1907, being valued at $349,311; but the greatest amount of cut mica was produced in 1910 when 2,476,190 lb. or nearly three times the product of 1912 were produced.

The figures show a curtailment of production and a number of producers were again shut down in 1912. With but few exceptions no new producers are likely to start mining in the near future.

STATISTICS OF MICA IN THE UNITED STATES.
(In pounds and tons of 2000 lb.)

| Year. | Production. (a) | | | Imports. | | | |
|---|---|---|---|---|---|---|---|
| | Sheet. (b) | Scrap. | | Unmanufactured. | | Cut or Trimmed. | |
| | Pounds. | Tons. | Value. | Pounds. | Value. | Pounds. | Value. |
| 1899 | 97,586 | 6,917 | $50,596 | 1,709,839 | $233,446 | 67,293 | $42,538 |
| 1900 | 127,241 | 5,417 | 42,889 | 1,892,000 | 290,872 | 64,391 | 28,688 |
| 1901 | 360,600 | 2,171 | 19,719 | 1,598,722 | 299,065 | 78,843 | 35,989 |
| 1902 | 373,266 | 1,400 | 35,006 | 2,149,557 | 419,362 | 102,299 | 46,970 |
| 1903 | 619,600 | 1,659 | 25,040 | 1,355,375 | 288,783 | 67,680 | 29,186 |
| 1904 | 668,358 | 1,096 | 10,854 | 1,085,343 | 241,051 | 61,986 | 22,663 |
| 1905 | 851,800 | 856 | 15,255 | 1,506,382 | 352,475 | 88,188 | 51,281 |
| 1906 | 1,423,100 | 1,489 | 22,742 | 2,984,719 | 983,981 | 82,019 | 58,627 |
| 1907 | 1,060,182 | 3,025 | 42,800 | 2,227,460 | 838,098 | 112,230 | 77,161 |
| 1908 | 972,964 | 2,417 | 33,904 | 497,332 | 224,455 | 51,040 | 41,601 |
| 1909 | 1,809,582 | 4,090 | 46,047 | 1,678,482 | 533,218 | 168,169 | 85,595 |
| 1910 | 2,476,190 | 4,065 | 53,265 | (c)1,972,221 | 721,541 | | |
| 1911 | 1,887,201 | 3,512 | 45,550 | (c)1,467,688 | 469,089 | | |
| 1912 | 845,483 | 3,226 | 49,073 | (c)2,315,346 | 745,399 | | |

(a) Statistics for 1901 to 1912 inclusive are those of the U. S. Geological Survey. (b) The value of sheet mica being so widely variable, and so little indicative of commercial results, and all previous statistics being of doubtful accuracy, they have been omitted from this table. (c) Includes cut or trimmed.

The principal state for mica is North Carolina; New Hampshire, South Dakota, Virginia and Idaho are also producers. Virginia reported no production in 1910. In Idaho some activity is now shown and two companies were working in Latah County. In South Dakota no large producers operated in 1912. The product of the Asheville region has increased. It is reported that in 1912 the value from North Carolina was $256,600 as compared with $217,300 in 1911. This production in

[1] Douglas B. Sterrett, advance chapter, "Mineral Resources for 1912," *U. S. Geol. Surv.*, 1913.

1912 was 489,600 lb. of sheet mica valued $219,900 and 2490 short tons scrap mica valued $36,675. In 1911 the outputs were 454,653 lb. sheet mica worth $187,501 and 2347 tons valued $29,798.

The New Hampshire production in 1912 was valued $37,338 and in 1911 $44,927. This was divided in 1912 into 308,047 lb. sheet mica valued $32,238 and 264 tons of scrap valued $5100.

The mica mined in the United States is mostly muscovite or white mica; what phlogopite is obtained is in the form of a by-product and of scrap.

*Imports.*—The import duties on mica are as follows: Rough trimmed only or unmanufactured 5 cents per pound plus 20 per cent.; cut or trimmed or manufactured 10 cents per pound plus 20 per cent.; ground 20 per cent. It is expected that the importers will ask for a reduction on pure mica, leaving the duty on built-up mica as it is. Imported competitive mica comes practically from India where labor is very cheap. Very little built-up mica is imported, and it is claimed that this requires a tariff for protection, equal to the difference between foreign and domestic labor. It is also claimed that the duty on cut or closely trimmed mica should be about twice that on uncut or roughly trimmed mica. In 1910 a 20 per cent. reduction took place on the import duties. The cost of mining in India is stated[1] as only $0.024 per pound, as compared with a cost of 12 cents in the United States. The waste in India is only 6 cents per pound as compared with $0.30 in the United States, while the labor per pound in India is 2 1/2 cents as compared with 12 cents in the United States. This makes a total of $0.54 as compared with 10.9 cents in the foreign country. In 1907 muscovite mica, which is superior to the phlogopite or the Canadian amber, cost $0.51 imported, of which 14 cents was duty.

The imports for consumption in 1912 are divided as follows: Manufactured or rough trimmed only, 1,900,499 lb. valued $649,236; cut or trimmed, plates or built up, 88,632 lb. valued $99,736; ground, $6611. The declared value does not appear to have fluctuated. The sheet mica, unmanufactured, is calculated at about 34 cents, an advance of about two cents from 1911.

The export of foreign mica in addition to the imported as stated, were: 19,515 lb. in 1911 valued $9113, whereas in 1912, 4558 lb. valued $1240 were exported.

*Prices.*—In giving the value of the United States production as above, a low average figure is used, viz., 33.4 cents per pound; if duty be added to the 34 cent import price it is believed that this more nearly represents the average value of the United States production. Com-

[1] W. V. Brown,

paratively, however, the figures show that a rise in domestic average prices has undoubtedly taken place. According to the *U. S. Geol. Surv.* this would be more than double, but as the prices are so variable for different grades no analysis can be made without figures giving the proportions of different kinds produced. Prices are usually quoted for culled sheets, as the splittings go to manufacturers directly.

Owing to the high prices the use of the so-called mica plate is on the increase. This is made up of small mica films and although this material is cheaper than the product it is now rising in price. The mica plate product was being made to such an extent that competition among the makers has had a tendency to keep the price low.

## Mica in Foreign Countries

The principal source of supply continues to be British India, that is Calcutta and Madras. The European market for high-grade mica is supplied from this source. A few large consumers obtain mica directly from the mines. The shipments to London which may be considered the market for mica, were from Calcutta 51,646[1] cwt. valued 3,717,882 Rupees in 1911, and 37,900 cwt. valued 2,271,155 Rupees in 1912.

The market advanced for all grades of mica, the demand being greater than the supply. Fairly regular shipments from German East Africa supply the German market directly; such shipments amounted to probably 200 to 300 cases, 65 lb. net each. The quality of this mica is not the best and much of it is black spotted. The amber mica that comes to London from Africa and Mexico in large quantities is poorly trimmed and not of good quality and requires regrading and selling at a loss to the producers. Amber mica mining developed during the year and a larger quanity of this electrical mica was absorbed by the trade. Most of the Canadian amber mica is consumed in the United States; prices of labor are high and it cannot compete with the mica from India,

Ninety-nine per cent. of the mica coming on the market in London, is in an uncut condition, some of it being sickle trimmed (this applies to Calcutta mica) and some of it rectangular trimmed (this applies to Madras mica). The shipments of cut and ground mica from India or any other mining centers, to London, are very small. Ground mica is mostly imported into Europe from the United States.

Of the chief producing countries India ranks first, the United States second, and Canada third.

*Canada.*—The exports of mica in 1911 were 693,940 lb. valued $309,546 and in 1912 were 895,338 lb. valued $334,054.

[1] Figures and other information from D. Jaroslow, 19 Tower Hill, London.

The mica deposits of Canada are described in the report of H. S de Schmid.[1]

Mining operation were restricted after the slump of 1907 and 1908 and a number of properties are still closed down on account of an unprofitable price. The production in 1911 was reported as $119,863; in 1912 the value stated by the department of mines[2] was $104,393.

In Quebec the mica market in 1912 was satisfactory and the production increased from $76,428 to $99,463. As usual the production comes entirely from the Gatineau and Lievre Rivers district, northeast of Ottawa.

Ontario reports a decrease of $6424 in its mica production; in 1912 the amount produced was 318 short tons valued $36,634.

STATISTICS OF MICA IN CANADA.

| Year. | Production. | Total Exports. | Exports to U. S. (a) | Year. | Production. | Total Exports. | Exports to U. S. (a) |
|---|---|---|---|---|---|---|---|
| 1903..... | $177,857 | $196,020 | $196,470 | 1908.... | $139,871 | $198,839 | (b)$140,166 |
| 1904..... | 160,777 | 198,482 | 137,191 | 1909.... | 147,782 | 256,834 | (b)137,383 |
| 1905..... | 178,235 | 179,049 | 121,560 | 1910.... | 143,409 | 299,107 | (b)287,048 |
| 1906..... | 303,913 | 581,919 | 328,991 | 1911.... | 119,863 | 309,546 | (b)308,851 |
| 1907..... | 312,599 | 422,172 | 596,321 | 1912.... | 104,393 | 334,054 | (b)217,868 |

(a) Fiscal year ending June 30. (b) Fiscal year ending March 31.

The methods of mining in Canada on account of the similarities of the deposits, are few, the usual plan being to open small pits. From the point of view of the miner, the difficulty with mica deposits is that no certain indications exist for following the mineral. Three types of deposits are: first, true fissure deposits; second, pocket and fissure deposits; third contact deposits. The second is most frequently met with. In this case the accumulations of mica occur in the mass of rock, and these pockets are frequently joined by fissures carrying more or less mica. Such fissures may traverse as mere stringers, or they may come to an abrupt end without any rule. The true fissures which are of rare occurrence are easier to follow but are generally of short length, the width being not more than 6 ft. In addition they are usually of low grade, the mica being much crushed. Parallel fissures sometimes occur, as in the Bobs Lake mine, Bedford, Ont. The distance between more than a dozen parallel leads in this case, varies from 8 to 15 ft.

One of the deepest mines is the Lake Girard, 21 miles north-east of Ottawa. During its operation from 1891 to 1896, this mine produced about 4 1/2 tons per day of rough cobbed mineral mostly from a depth of 210 ft. The Lacey mine, near Sydenham, Ont., is 185 ft. in depth, but is now operated by open cut which has reached a depth of 70 ft. This mine

[1] "Mica, Its Occurrence, Exploitation, and Uses." *Mines Branch Dept. of Mines*, Canada, 1912.
[2] Preliminary figure.

is at present the largest producer of mica in Canada. The output is shipped in a rough cobbed state, to the shops at Ottawa where the sheets are thin split. The finished product is sent to the General Electric Company, at Schenectady, N. Y., and is manufactured into mica-plate.

The Blackburn property belongs to Messrs. Blackburn Bros., of Ottawa, and is the next important mine in operation to-day. It is located 18 miles northeast of Ottawa. Another property, of historic interest, is the Wallingford. This property like many others in Canada, was worked for phosphate, the refuse mica being thrown on the dump. The total output of trimmed mica here has been estimated at 3600 tons.

A number of such dumps resulting from what were originally phosphate mines, have yielded large quantities of valuable mica, but the amount of small waste mica scattered about the various mines is being consumed rapidly although four to five years ago the dumps were regarded as useless.

AVERAGE ANNUAL DISTRIBUTION OF INDIAN MICA EXPORTED DURING THE YEARS 1903 TO 1908 INCLUSIVE. (*a*)
(1 cwt. = 112 lb.)

| Exported to | Average Quantity. | | Average Value. | | Value per cwt. £ |
|---|---|---|---|---|---|
| | Cwt. | Per cent. of total. | £ | Per cent. of total. | |
| United Kingdom | 17,226 | 52.8 | 102,307 | 61.9 | 5.94 |
| United States | 4,781 | 14.7 | 29,497 | 17.8 | 6.17 |
| Germany | 7,391 | 22.7 | 21,337 | 12.9 | 2.89 |
| Belgium | 1,050 | 3.2 | 3,551 | 2.1 | 3.38 |
| France | 558 | 1.7 | 2,497 | 1.5 | 4.47 |
| Other countries | 1,599 | 4.9 | 6,214 | 3.8 | 3.89 |
| Average Total | 32,605 | 100.0 | 165,403 | 100.0 | 5.07 |

(*a*) *Records*, Geol. Surv. Ind., Vol. XXXIX.

WORLD'S PRODUCTION OF MICA. (*a*)
(Five-year periods.)

| Period. | Canada. | India. | | United States. | Total. |
|---|---|---|---|---|---|
| | Value. | Value. | Per cent. | Value. | Value. |
| 1894–1898 | £72,991 | £316,016 | 68.08 | £75,147 | £464,154 |
| 1898–1903 | 160,552 | 426,851 | 60.14 | 122,382 | 709,785 |
| 1904–1908 | 285,351 | 867,553 | 61.78 | 251,299 | 1,404,203 |
| Total | £518,894 | £1,610,420 | 62.50 | £448,828 | £2,578,142 |

(*a*) *Records*, Geol. Surv. India, Vol. XXXIX.

*South Africa.*—The geology of the Murchison Range and District[1] gives an account of the mica deposits southeast of Leydsdorp, at Malelane, and other localities. The most extensive occurrence associated with the Olifants River mica fields, 22 miles southeast of Leydsdorp, is in pegma-

[1] Mem. No. 6, 1912, *Union of South Africa, Mines Dept. Geol. Surv.*

tite which intrudes older granite, gneisses and schists. The mica is a muscovite of pale smoky-quartz color. The crystals are 2 or 3 in. in thickness. The mica is trimmed to plates not larger than 5 to 6 in. Some of these are transparent and free of defects. The deposits have not been mined extensively and are only in the prospecting stage.

*United Kingdom.*—The mica produced in the United Kingdom was 21,743 tons, valued at £9341 in 1910. In the year 1911 the figures were 25,335 tons, valued at £8748.

This is obtained as a by-product in preparation of china-clay, and comes mostly from Cornwall.

The foreign and colonial exports of mica from the United Kingdom to the United States during the year 1910, were valued at $136,446, and during 1912, $128,865.

Uses of Mica.—The deposits of phlogopite mica furnish the amber mica of the trade. "White" mica or muscovite is seldom white or colorless excepting in thin sheets. In thicker sheets the Canadian white mica is pale green or smoky in color; the Indian muscovite has a reddish tint.

The quality of mica from the experience in mining in Canada has been found to be variable in the same deposit. One portion of a pocket or vein may yield perfect crystals, while another contains only broken and crushed mineral, or a great deal of foreign mineral matter, usually calcite or quartz. These latter between the laminæ affect the splitting quality. The valuation of a mica deposit based upon surface indications, must necessarily be tentative.

The different grades of mica may be supplied from the same deposit. The crude product may be sold as rough cobbed mica, or it may be shaped and trimmed to rough sheets known as culled or thumb trimmed, or they may be split into thinner sheets, selling this product to manufacturers. In this form the sheets are 1 to 2 mm thick, and are known as splittings. The utilization of smaller grades of mica in the form of the smallest scrap is now accomplished for paint manufacture and for lubricants.

The most extensive use for sheet mica is in the manufacture of electrical apparatus, in which it is used in built up plates, large or small. White mica is suitable for all insulation excepting for commutators; for these the amber mica is preferred; one reason for this is the hardness or wear being about the same as that of the copper. The insulating properties of the mica is not affected by specks which do not affect the splitting; such included minerals, even magnetite, when extremely thin do not affect the insulating qualities. When ground mica is used for making insulators it must be free from metallic minerals. The test for

mica as an insulator is its ability when subjected to high voltages to withstand fusion. In this respect India and Canada micas rank first; that from North Carolina last. The use of sheet mica for stoves and lamp chimneys and shades continues. Some grades of ground mica are used between sticky sheets of roofing material.

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# MOLYBDENUM

Molybdenum and ferro-molybdenum are manufactured in the United States, but the annual production of ore is insignificant and no molybdenum ore deposits have been worked in the United States in recent years on a commercial scale. The Primos Chemical Company, of Primos, Pa., manufactures molybdenum among its other products. The Company states that the demand for molybdenum is about the same, and that there is no increase in the consumption. From 1900 to 1905, the consumption was at its greatest, this company alone producing at the rate of more than 50 tons of molybdenum per year. The consumption in 1906 dropped to a few tons per year, but is now gradually increasing to perhaps 2 tons per month in the United States. The use of the molybdenum and ferro-molybdenum is in connection with tungsten in most of the high-class tool steels. It is also used in connection with vanadium for the same purpose. In steel castings for railroad work, molybdenum is used up to 1 per cent. European armor plates are stated to contain up to 2 per cent. of molybdenum. The alloy known as ferro-molybdenum-tungsten is manufactured by the same firm, the molybdenum being three times the tungsten. To this alloy vanadium is sometimes added according to specifications, from 1 to 7 per cent.

Molybdenum and ferro-molybdenum are imported to some extent into the United States. That valued at more than $200 per ton is dutiable at 20 per cent., and that valued at less, at 25 per cent. The ferro-molybdenum imported into the United States in 1912 amounted to 3.5 tons valued at $4670. Offers for molybdenum ore are occasionally received from Europe. The price in the United States ranged from 25 cents to 40 cents per pound of molybdenum-sulphide. The price of ferro-molybdenum is about $1.60 per pound of the molybdenum contents.

The deposits in the United States are in Arizona, Maine, Oregon, Nevada and Washington.

In Canada, according to Dr. T. L. Walker,[1] twelve promising deposits are likely to repay further prospecting.

The molybdenite ore exported from Australia in 1912 was 2873 cwt. valued at £15,538. The production of New South Wales in 1911 was 20.65 tons valued at £2591, and in 1912, 56.55 tons valued at £37[illegible]. Queensland produced 99.5 tons valued at £13,278 in 1911, and 10[illegible] tons valued at £17,349 in 1912.

[1] Report on Molybdenite Ores of Canada. Dept. of Mines, Ottawa, Canada, 1911.

Small veins of molybdenite are found nearly all over Norway. The export has in some years amounted to 40 tons, with a content of between 90 and 100 per cent. $MoS_2$. The most of this molybdenite has come from "Storknaben Grube," at Flekkefjord, owned by Messrs. Geo. Blackwell Sons & Co., and the Albany, near Liverpool. A new mill is now being built in the same district at "Lilleknaben." The name of the company owning the mine is "Kvins Molybdenitekompani," Stavanger.

Small shipments of wulfenite were made from Mexico, from the lead mine near Cuchillo Parado, on the Conchos river in Chihuahua. This lead molybdenite, containing more than 25 per cent. $MoO_3$, is worth $100 per ton.

Molybdenum has been used in preparing new alloys with ferro-chrome, for acid-resisting purposes.[1] 2 to 5 per cent. molybdenum is added to ferro-chrome containing little or no carbon, and about 10 per cent. chromium. The alloy can be manipulated by the usual workshop methods. The use of molybdenum in a molybdenum-tungsten therom-couple, has been suggested by Carl Hering.[2] These metals have a high fusing point, but require protection from any metal bath. If a suitable protecting tube can be invented, this will be a new use for molybdenum. The voltage curve between these metals has been determined on wire, some of which is now on the market.[3]

Molybdenum ore concentrated to 92 per cent. molybdenite is worth about $400 per ton. Copper is undesirable and 2 to 3 per cent. is prohibitive. Low-grade ore is worth less per unit; 25 per cent. $MoS_2$ is worth only $25 per ton. In the concentration of ores progress has been made in testing work, but no plant is working on ores for commercial production.

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[1] Prof. Borchers, *Engineer*, July 26, 1912.
[2] *Trans. A. I. E. E.*, December, 1912.
[3] Edwin F. Northrup, *Met. and Chem. Eng.*, Jan., 1913, p. 45.

# MONAZITE SAND

The mineral monazite is a cerium phosphate in which part of the cerium is replaced by thorium, lanthanum, neodymium and praseodymium. The mineral is used for producing thoria and ceria, and the percentage of thoria determines the value. The principal producer of monazite is Brazil. Up to the year 1909, a considerable domestic output in the United States came from the Carolinas. Unfortunately the industry could not compete with the foreign mineral or the thorium salts, when the duty was reduced from 6 to 4 cents per pound. The producers in North Carolina work the deposits in a very small way. The ownership of the scattered deposits is vested in thousands of small land owners. They have recently petitioned the Ways & Means Committee, explaining their plight and asking that the duty in any new tariff be maintained at 6 cents per pound on monazite and 60 per cent. on thorium nitrate, and also asking a reduction on thorium mantle scrap from 40 per cent. to 20 per cent.

During the calendar year 1912, there was no monazite produced in the United States, except possibly trifling amounts for the purpose of holding leases. It is probable that 5000 lb. of crude monazite sand, estimated to contain 1272 lb. of monazite, were obtained in this way. Occasionally some monazite is produced incidentally in the production of gold from placers, as in the case of the Catawba Dredging Company, at Morgantown, N. C. The Capt. Mill's mine at Brindletown, N. C., also is worked by lessees that obtain small quantities of the mineral.

The following table gives the production of the United States, which is now practically nil:

The greatest production of monazite took place in 1895. The greatest value of a somewhat smaller amount was produced in 1905, although in that year the price was about as it has been lately. The highest price of monazite for the domestic product was 18 cents per pound in 1906. The production reported in the table is refined sand, and while it appears that prices have increased for this product in recent years, the grade of the material has also improved. Not only is the American industry for monazite unable to compete with the imported product, but the manufactured thorium nitrate is also imported in large quantities.

MONAZITE PRODUCTION IN THE UNITED STATES.

| Year. | United States. (a) | | | North Carolina. (b) | | |
|---|---|---|---|---|---|---|
| | Pounds. | Value. | Per Pound. | Pounds. | Value. | Per Pound. |
| ..... | 546,855 | 36,193 | 0.066 | 364,570 | 24,129 | 0.066 |
| ..... | 1,573,000 | 137,150 | 0.087 | 1,048,667 | 91,433 | 0.087 |
| ..... | 30,000 | 1,500 | 0.050 | 20,000 | 1,000 | 0.050 |
| ..... | 44,000 | 1,980 | 0.045 | 29,333 | 1,320 | 0.045 |
| ..... | 250,776 | 13,542 | 0.054 | 167,184 | 9,028 | 0.054 |
| ..... | 350,000 | 20,000 | 0.057 | 233,333 | 13,333 | 0.057 |
| ..... | 908,000 | 48,805 | 0.054 | 605,333 | 32,537 | 0.054 |
| ..... | 748,736 | 59,262 | 0.079 | 499,157 | 39,508 | 0.079 |
| ..... | 802,000 | 64,160 | 0.080 | 534,667 | 42,773 | 0.080 |
| ..... | 862,000 | 64,630 | 0.075 | 773,000 | 58,694 | 0.076 |
| ..... | 745,999 | 85,038 | 0.114 | 685,999 | 79,438 | 0.116 |
| ..... | 1,352,418 | 163,908 | 0.121 | 894,368 | 107,324 | 0.120 |
| ..... | 846,175 | 152,312 | 0.180 | 697,275 | 125,510 | 0.180 |
| ..... | 547,948 | 65,754 | 0.120 | (c)456,863 | 54,824 | 0.120 |
| ..... | 422,646 | 50,718 | 0.120 | (c)310,196 | 37,224 | 0.120 |
| ..... | 541,931 | 65,032 | 0.120 | (c)391,068 | 46,928 | 0.120 |
| ..... | 99,301 | 12,006 | 0.121 | 83,454 | 10,104 | 0.121 |
| ..... | 3,561 | 427 | 0.120 | 400 | 48 | 0.120 |
| ..... | 1,272 | 159 | 0.12 | *Nil.* | ..... | ..... |

tatistics are those of the U. S. Geological Survey. (b) Statistics for N. C. from 1893 to 1902 are s; those from 1903 to 1906 are from "The Mineral Industry of North Carolina"; those for 1910 ished by Joseph Hyde Pratt, State Geologist. (c) Statistics for 1907, 1908, and 1909 were col- intly by the U. S. Geological Survey and the N. C. Geological and Economic Survey.

ıe following table shows the imports of thorium-nitrate and of zite in recent years:

IMPORTS OF THORIUM NITRATE AND MONAZITE. (a)

| | Year. | Pounds. | Value. | Per Pound. |
|---|---|---|---|---|
| ı nitrate entered for consumption ..... | 1902 | 42,815 | $131,350 | $3.07 |
| | 1903 | 64,520 | 232,155 | 3.59 |
| | 1904 | 58,655 | 249,904 | 4.26 |
| | 1905 | 52,378 | 269,504 | 5.14 |
| | 1906 | 40,090 | 139,929 | 3.49 |
| | 1907 | 51,441 | 152,666 | 2.96 |
| | 1908 | 65,289 | 173,239 | 2.65 |
| | 1909 | 125,088 | 236,057 | 1.89 |
| | 1910 | 108,597 | 218,713 | 2.01 |
| | 1911 | 121,111 | 238,841 | 1.97 |
| | 1912 | 117,485 | 225,386 | 1.92 |
| e sand (and thorite) general imports..... | 1909 | 661,880 | 57,545 | 0.0869 |
| | 1910 | 2,427,732 | 217,360 | 0.0895 |
| | 1911 | 1,781,290 | 157,229 | 0.0883 |
| e sand (and thorite) entered for..... mption. | 1909 | 110,088 | 9,543 | 0.0867 |
| | 1910 | 453,554 | 39,699 | 0.0875 |
| | 1911 | 705,149 | 60,542 | 0.086 |
| | 1912 | 556,959 | 47,334 | 0.085 |

tatistics from 1902 to 1908 are those of the U. S. Geological Survey; those for 1909 and 1910 were d by the Bureau of Statistics of the Department of Commerce and Labor.

ıe value of the imported products is decreasing in recent years. erly the thorium convention of 1909 attempted to control prices, ow contracts for the crude minerals are made independently. In he value of the cerium imported for consumption was $7083.

*North Carolina.* (By Dr. J. Hyde Pratt).—No monazite was produced in North Carolina during 1912 on account of there being no demand at prices which would make it profitable for the miners. Thoria is the constituent of the monazite that is chiefly desired and it is obtained as a nitrate. There is, however, being imported into this country thorium nitrate, cheaper apparently than it can be manufactured from the American monazite.

Although commercially the monazite industry has been at a standstill for the past year in this State, yet it will be of interest to those who are producers and users of monazite to know of an occurrence of this mineral that has recently been found in this State, where the monazite occurs in large masses.

The occurrence referred to is in Madison County, North Carolina, on a tract of land owned by Mr. N. P. M. Corn, 3 miles southwest of Mars Hill and 6 miles nearly due east of Marshall.

The country rocks of this section are Carolina gneiss and Cranberry granite named and described by Mr. Arthur Keith.[1] The Carolina gneiss is of Archean age and consists chiefly of mica gneiss and mica schist but includes other gneisses, granites and diorites with small lenses of marble. The origin of this Carolina gneiss is uncertain, but it is possible that most of the mass was once a granite and that it has been metamorphosed into its present condition. In this particular vicinity this Carolina gneiss occurs as outliers from the main formation and is not interbanded with the Cranberry granite. Immediately to the east there is a large mass of Roan gneiss and this is also observed farther to the west. The Cranberry granite as it occurs in this vicinity is also in the form of outliers or apophyses from the main mass lying to the north and west. This granite as described by Mr. Keith, is an igneous rock composed of quartz and orthoclase and plagioclase feldspar with biotite, muscovite and, in places, hornblende. Accessory minerals are magnetite, ilmenite, garnet and epidote. This granite occasionally contains pegmatite areas and, on the Whiteoak Creek, a great deal of the gneiss and granite was pegmatized.

Outcrops are few and occasionally small boulders of the partially decomposed granite are observed containing more or less epidote and ilmenite forming a sort of a ledge running around a hill about a third of the way to the top. About 100 ft. up the hillside a shaft sunk to a depth of 45 ft. shows decomposed rock requiring no blasting.

This rock had the appearance of being decomposed Cranberry granite. The section exposed by the shaft showed the rocks to be more or less pegmatized and to carry monazite the whole depth of the shaft. The monazite seemed to occur in the pegmatized band of the rock which, in

[1] *U. S. Geol. Surv., Asheville Folio*, No. 116, 1904, pp. 2 and 3.

the shaft as exposed, had a width of 2 1/2 to 4 ft. and does not occur in any sense in a vein formation.

The monazite which is of a clove-brown color, was found in fragments or rough crystals varying from pieces the size of a pea up to a large rough crystal that weighed almost exactly 60 lb. No attempt was made at this time to determine the percentage of monazite that the rock would carry. One or two pans full of the monazite-bearing portion of the rock were dug out, which gave nearly a pound of monazite.

As stated above, the monazite is in the form of irregular fragments, rough crystals and cleavable masses. One of the best crystals observed was a part of a mass that weighed 6 1/2 lb., which was made up of crystals in parallel position with some of the faces very perfectly developed. Another crystal, which was well terminated, weighed 12 oz. It was 2 3/4 in. long in the direction of the *b* axis and 1 1/2 in. in the direction of the *a* axis and 2 1/4 in. long in the direction of the *c* axis. The prismatic facies of the *a* pinacoid were well developed as was also the unit pyramid *w*. The lower end of the crystal showed no terminations. The facies observed on these crystals were identified by means of the contact goniometer and were as follows: *a* (100); *m* (011); *w* (101); *v* (111).

The basal plane *c* was not observed on any of the crystals but was observed as one of the parting or cleavage planes. Parting planes were also very prominently developed parallel to *m*.

The masses of the monazite were very pure and one analysis to determine the percentage of monazite in the masses showed it to contain 99.5 per cent. monazite. No chemical analyses have been made of the mineral beyond the determination of thoria. This determination, which was made in the laboratory of the Welsbach Light Company, showed this monazite to contain 5.06 per cent. thoria, which is equal to the percentage of thoria in the best commercial monazite found in the South Mountain region.

The size of the crystals of monazite their distribution and the possibility of developing into an occurrence of commercial value make the discovery a most interesting one.

*Texas.*[1]—A detailed account of the rare minerals of the Llano Burnet region, Baringer Hill, Texas, is given by F. L. Hess,[2] and Sidney Paige.[3]

Baringer Hill is about 100 miles northwest of Austin on the west bank of the Colorado River. The nearest railroad point is Kingsland, 12 miles to the south. It is a low mound rising 40 ft. above the river which has here a flood plain 1/4 mile wide. This hill is formed by a pipe

[1] Llano Burnet folio, U. S. Geol. Surv.
[2] Minerals of the rare earth metals at Baringer Hill, *Bull*, 340, 1908, pp. 286–94.
[3] Min. Res. of the Llano Burnett Region, Texas, with an Account of the Pre-Cambrian Geology, *Bull*. 450, 1911, pp. 38–88.

or short dike of pegmatite which has been more resistant to erosion than other rock; all the rock contains feldspar. The rare earth minerals fergusonite and gadolinite and also cyrtolite, are found in larger proportion in this pegmatite than in any other locality. The Nernst lamp Company owns the deposit, and works it occasionally to supply enough mineral for a number of months. The earth's yttria and zirconia are the principal ones extracted, as the associated earths ceria and beryllia volatilize in the electric glower lamp. Only a few hundred pounds of minerals are necessary for a year's supply. The excavations are shallow thus far and the minerals are decomposed more or less.

Allanite has been found 2 1/2 miles northwest of Kingsland. Gadolinite has also been found 2 miles east of Baringer Hill, and 1/2 mile west of Shiloh Church, where a shallow trench exposes some pegmatite. The above localities are in a red-granite region, but one locality outside of the red granite also shows small masses of weathered rare earth minerals.

## Foreign Countries

*Brazil.*—The occurrence and treatment of monazite and thorite in Brazil are described in Mineral Industry, Vol. XX, p. 532. The exports from Brazil in 1910 and 1911 are as follows:

| | 1910. | | 1911. | |
|---|---|---|---|---|
| | Metric Tons. | Dollars. | Metric Tons. | Dollars. |
| Monazite sand | 5,437 | 631,251 | 3,686 | 539,293 |
| United States | 1,100 | 130,650 | 700 | 101,352 |
| Germany | 2,636 | 303,953 | 1,890 | 280,996 |
| France | 1,691 | 195,466 | 1,096 | 156,951 |

In 1912 the mineral exports of monazite were 3398 metric tons. The exports from Bahia, alone, in 1910 amounted to 1244 metric tons, valued at $175,142.

The engineer appointed by the Minister of Finance to report on the tenders sent in for the exploiting of monazite sands in the Union has decided that the tender sent in by G. Chouffour is the better of the two. The other was that of the Banco Hypothecario e Agricola do Estado do Espirito Santo. The favored tender undertakes to export 35,000 tons while the contract is in force, which will be a minimum period of 14 years. Government will also receive 50 per cent. of the net profit on nitrate of thorium. The engineer calls the attention of the minister to the fact that monazite sand has been found in large quantities and of excellent

quality in Hindustan, while it is also richer in thorium than the Brazilian sand. The market price at present is about 500,000 mr. (about $163.90 United States currency at present rate of exchange for Brazilian paper milreis) per ton.[1]

## ZIRCONIUM

The zirconia used for various purposes, such as a refractory material, in increasing quantities, is now largely obtained from the mineral baddeleyite. Zircon ($ZrO_2$, $SiO_2$), has also been used for this purpose, but the process of extracting the zirconia is much more expensive.

Böhm states that large quantities of zircon oxide are found near Sao Paulo, Brazil, and that much of this material known as "Baddeleyite" was shipped to Germany.

Baddeleyite[2] occurs in large quantities in certain gravels of the Serra de Caldas in Minas Geraes, Brazil, and is stated to occur in three forms, the composition of which is shown in the following table:

| | Glassy Fragments. | Stony Fragments. | Pebbles. |
|---|---|---|---|
| | Per cent. | Per cent. | Per cent. |
| Zirconia, $ZrO_2$ | 94.12 | 88.40 | 74.48 |
| Titanium dioxide, $TiO_2$ | 0.98 | 3.12 | 1.35 |
| Ferric oxide, $Fe_2O_3$ | 3.22 | 4.07 | 10.26 |
| Silica (free), $SiO_2$ | 0.43 | 2.50 | 14.08 |
| Silica (combined), $SiO_2$ | 1.98 | 3.39 | |

The glassy variety can be freed from most of its ferric oxide by mechanical means, yielding a product which contains about 98 per cent. of zirconia. Various grades of prepared powdered zirconia are now offered for sale at the following rates:

| Percentage Composition. | Price per Metric Ton |
|---|---|
| Zirconia, 90 to 92; ferric oxide, 1.0; silica, 8.0 | £35 |
| Zirconia, 90 to 92; ferric oxide, 7.0; silica, 1.0 | £36 |
| Zirconia, 98 .00; ferric oxide, 0.8; silica, 1.0 | £50 |

In preparing furnace hearths and crucibles, one method is to make a mixture of 90 per cent. of zirconia and 10 per cent. of monazite, with 10 per cent. of phosphoric acid. Another method is to use starch as a binder and fire the dried crucibles in an electric furnace at a temperature of 2000 to 2300° C. These crucibles are on the market in Germany. The material has an advantage in having a low coefficient of expansion. The crucible plunged red hot into water, will not fracture.

[1] From the *Review*, Rio de Janeiro; *Daily Cons. and Trade Rep.*, Sept. 10, 1912.
[2] *Bull. of the Imperial Institute*, January, 1913.

Zirconia ware is said to be suitable as an insulator of electricity up to 2000° C. The product siloxide has been described in MINERAL INDUSTRY, on p. 543, Vol. XX. Other uses of zirconia are as a pigment of good covering power and non-poisonous, in the form of silicate, basic carbonate, phosphate, etc.; in the "glower" of the Nernst lamp; as "kontrastin," in place of bismuth salts for defining X-ray photographs of the intestines. It has also been used in the form of acetate, for weighting silk. Twenty per cent. ferro-zirconium has been found beneficial in treating steel, 1 per cent. being used.

*Zirconiferous Sandstone.*—The occurrence of zircon sandstone has been reported near Ashland, Virginia.[1] The area lies south of the Anna River on the western edge of the Coastal Plain. Specimens of the sandstone when treated and washed yielded from 12 to 29 per cent. by weight of zircon. The crystals of this zircon material are small in size, three-fourths of it passing through a 100-mesh sieve. The zircon is associated with quartz and ilmenite but no magnetite was found. The deposit is supposed to be similar to that of the black sand beaches of New Jersey, California, Oregon and other coasts. Pieces of zircon have been found ten or fifteen miles southwest, near Goulden post office, 3 in. in diameter, weathered out of pegmatite dikes. Massive zircon has been observed without crystal outline in the pegmatites of Amelia County, in Virginia, measuring 4 to 6 in. It is probable that many such zircon-bearing deposits along the edge of the Piedmont Plateau will be discovered.

## RARE EARTHS

Many rare elements are now isolated in a pure state. The application for making alloys with more common metals, and the study of the properties of these is rapidly advancing. Each one of these alloys opens a new field on account of their different properties. Under rare earths proper would be included the oxides of such metals as cerium and thorium, and for practical purposes also zirconium.

A number of the rarer metals and minerals which they form, are described by Waldemar T. Schaller,[2] The method of quantitative and qualitative analysis of such earth as the oxides of Ce, Dy, Er, Eu, Gd, Ho, La, Lu, Nd, Pr, Sc, Sm, Tb, Tu, Y, Yb; Th, Ti, Zr; Nb, and Ta, is given in a volume published by R. J. Meyer and O. Hauser.[3] A chapter treats of special methods used in the thorium-compound and gas-mantle industries.

[1] Thomas L. Watson and F. L. Hess, *Bull.* 530, *U. S. Geol. Surv.*, 1912, p. 165.
[2] *Bulletin* 509, "Mineralogical Notes," Serial No. 2, *U. S. Geol. Surv.*, 1911.
[3] Die Analyse Der Seltenen Erden Und Der Erdsaeuren, Vols. XIV to XV of "Die chemische Analyse." Ferdinand Enke, publisher, Stuttgart.

*Strüverite in Perak.*—Some strüverite was recently found in the Kuala Kangsar district, Perak, Federated Malay States, which, on analysis, gave: $TiO_2$ 45.74; $Ta_2O_5$, 35.96; $Nb_2O_5$, 6.90; FeO, 8.27; $SnO_2$, 2.67.[1] The only constituent likely to be of present value is tantalum.

*Scandium Extraction.*—Scandium may be separated from the wolframite minerals (double tungstates of iron and manganese) of Zinnwald and Altenbnrg; and the copper minerals of Sadisberg[2] hydrochloric-acid solution, is treated by boiling with hydrofluosilicic acid. The precipitated fluorides are then transformed into sulphates by sulphuric acid and precipitated as hydrates by ammonia and again gotten into hydrochloric-acid solution.

To this solution is then added hydrogen sulphide, after which a treatment with sodium hyposulphite is given. After decomposition of the hydrosulphite by the hydrochloric acid, the whole is precipitated by oxalic acid. In this method all the substances accompanying scandium (lead, copper, iron, manganese, other rare earths, and yttria) are eliminated, with the exception of thorium. To effect this separation advantage is taken of the insolubility of the double carbonates of scandium and sodium $Sc_2Na_2(CO_3)_76H_2O$. in a solution of boiling soda. The separation of, thorium and of other rare earths can also be made with success by means of potassium iodate, which throws down thorium iodate, in a nitric-acid solution.

*Extraction of Thoria.*[3]—Phosphorus Compounds interfere with the efficiency of mantles. The Welsbach Light Company, of Gloucester City, N. J., controls a process for efficiently eliminating these compounds, from thorium salts obtained in treating sands. Usually monazite is treated by converting the earths into insoluble oxalates. Other methods of treating the sand are by means of fusion with alkaline carbonates, and leaching the phosphates out with water, dissolving the residue in suitable acid and then separating the earths.

Monazite sand in round numbers, has the following composition: phosphates 29 per cent.; cerium earths 31 per cent.; didymium earths 31 per cent.; silicates 1.50 per cent.; Thorium (silicates and perhaps phosphates), 6.50 per cent.

Silica or silicate, is a variable constituent which must be taken care of. The work of Kress and Metzger[4] indicates that thorium does not occur as the silicate in monazite.

To overcome the expense of subsequent grinding it is found that the addition of fluorspar in the electric fusion of the sand with carbon, helps

[1] *Chem. Trade Journ.*, Mar. 23, 1912.
[2] *Metaux et Alliages*, October, 1912.
[3] Abstract from paper by Professor Bakerville, *Eighth Intl. Congr. of Appl. Chem.*
[4] *Journal American Chemical Society*, 1909, XXXI, 640.

the matter to some extent, avoiding some of the silicon carbide. An application for letters patent on a method of disintegration, has been made by the author. He incorporates calcium carbide with the fused mass, which will disintegrate when thrown into water. The objection that thorium and rare earth carbides decompose with the calcium carbide, appears to be trivial on account of the slowness of decomposition of the former. Satisfactory results were found with a charge as follows: Monazite sand 1.0 lb; carbon (petroleum coke), 0.80 lb; fluorspar 0.15 lb.

The mixture is subjected to electric heat, (35 volts and 125 amperes) for 1 1/2 hours, until phosphorus ceases to come off. The mass is allowed to cool and to decompose slowly by exposure to the air or in water. The dissolved suspended calcium hydroxide is removed by washing. The residue is treated with hydrochloric acid and thorium separated from the solution.

*Thoria Recovery.*[1]—A means of preparing pure thoria by phosphorous acid is given by F. Wirth.[1] A cold saturated solution of disodium phosphite, $Na_2HPO_3$, $3H_2O$, is added, drop by drop, with stirring, to a boiling solution of thorium and trivalent earth metals (*e.g.*, that obtained by the decomposition of monazite sand), which should contain 15 to 20 per cent. of free sulphuric acid, and, after some hours, the flocculent precipitate of thorium phosphite, which at once separates, is brought on to a hardened filter, washed with water containing sulphuric acid, rinsed into a dish, dried on the water-bath, and oxidized by treating with 20 c.c. each of fuming nitric acid and concentrated sulphuric acid (for 0.2 to 0.25 grm. of precipitate); the nitric acid is then completely removed by evaporation, the mixture of sulphate and phosphate dissolved in 800 c.c. of water, and the thorium separated by adding excess of oxalic acid to the cold solution. The phosphite precipitate may also be decomposed by prolonged boiling with potassium-hydroxide solution, the hydroxide precipitate being dissolved in dilute hydrochloric acid and the solution precipitated by oxalic acid.

*Volumetric Method for Thorium.*—A volumetric method for thorium has been worked out by Metzger and Zons which depends on the precipitation of thorium with a standard solution of ammonium molybdate, an excess of the precipitant being shown by the use of diphenyl carbazide on a spot plate.

The method as applied to monazite sand is as follows: Treat 1.0 grm. of the powdered sand in a porcelain crucible with 10 to 15 c.c. concentrated $H_2SO_4$. Heat several hours, then cool and transfer crucible contents, a

[1] *Zeit. f. Angew. Chem.*, p. 1678, 1912.
[2] *Journ. Ind. and Eng. Chem.*, July, 1912.

little at a time, to 700 c.c. of water cooled to nearly 0° C. Allow to stand several hours (over night if convenient), to insure solution of the sulphates. Filter and wash.

Nearly neutralize the filtrate with ammonia, and add 50 c.c. of a cold saturated solution of oxalic acid. Allow to stand over night, filter, and wash the oxalate precipitate with dilute oxalic acid. Transfer precipitate and paper to a beaker, and add 20 to 25 c.c. of strong potassium-hydroxide solution and heat to boiling. Dilute, filter, and wash with hot water.

Dissolve the precipitate of rare-earth hydroxides off the filter with hot dilute nitric acid, and evaporate to dryness on a water bath. Add a few cubic centimeters of water and again evaporate to remove free acid. To the dry residue add 200 c.c. glacial acetic acid, dilute with 300 c.c. of water, add 1 grm. of sodium acetate, and stir until dissolved. The excess of acid holds up other rare-earth molybdates.

Titrate at room temperature with standard ammonium-molybdate solution. The standard solution contains about 20 grm. per liter of ammonium molybdate, but must be standardized on a known thorium salt. The ammonium molybdate should be added a few tenths of a cubic centimeter at a time, with a vigorous agitation after each addition, finally finishing drop by drop. The end point is reached when a drop of solution produces a pink coloration on the spot plate, with a drop of diphenyl carbazide.

*The Influence of Didymium on the Incandescent Color of Thoria.*—The difference in the impurities in thorium nitrate are discussed by Drs. V. Pasquero and P. Pizzorno, of the Geneva Laboratorio Chimico Municipal.[1]

*Incandescent Mantles.* (By Dr. Charles Baskerville).—Böhm, the author of "Das Gaslühlicht" (1905) and "Die Fabrikation der Glühkörper fur Gasglühlicht" (1910), recently published (*J. Gas. Ltg.*, 121, 33, 100, 181) a series of articles on the manufacture of mantles for incandescent gas lighting.

Cuprammonium-cellulose, Chardonnet and viscose silks are all used for the manufacture of mantles; mantles of artificial silk combine the high and well-maintained illuminating power of ramie fiber with a great elasticity of the ash skeleton, and are now coming largely into use. Cotton mantles decrease in brilliancy after use, while those of ramie fiber are fairly constant. Cotton and ramie mantles must be washed before impregnation in order to remove the fat and mineral matter, and to accomplish this the following process is employed: the mantles are soaked over night in a 2 per cent. solution of nitric acid, and the following morning they are centrifuged, treated with a dilute solution of ammonia,

[1] *Rassegna Mineraria Metallurgica e. Chimica*, Dec., 1912, p. 293 and p. 63.

and then thoroughly washed. They are next dried in a current of hot air, any imperfect ones being removed. The mantles are impregnated by being soaked in a 25 to 33 per cent. water solution of thorium and cerium nitrates in the proportion of 99 : 1, to which very small quantities of beryllium and magnesium nitrates are added to harden and impart strength to the ash skeleton. The soaking period varies from 1 to 2 minutes in the case of ramie or cotton mantles, and requires 5 hours for artificial silk mantles. The superfluous liquid is removed by passage through a wringing machine, and the quantity of salts left in the mantles may be varied by adjusting the rollers of the machine. The mantles are next dried at a temperature not exceeding 30° C., for which purpose the cotton and ramie mantles, which are cut into short lengths prior to impregnation, are stretched over glass cylinders, and the artificial silk mantles, which are impregnated in lengths, are run over wooden rollers. The upright mantles are next fitted with a sewn-on tulle head or with a patent head, and the latter is fixed by treating with a 50 per cent. water solution of aluminum and magnesium nitrates. The asbestos loop is next sewed on; the inverted mantles are drawn together with impregnated cotton, to form the "spider," and are then fastened on to the supporting ring. The mantle is shaped on a wooden shaper, and is then burned off by a Bunsen flame. The ash skeleton is dipped into a collodionizing solution, usually consisting of 100 parts of a 4 per cent. collodion solution, 40 parts of ethyl ether, 6.5 parts of camphor, and 3.5 parts of castor oil. After drying rapidly at 50–60° C., the mantles are trimmed to the right length, sorted out into different qualities and the imperfect ones rejected.

Gas mantle manufacture[1] from artificial silk is getting to be an important French industry. While the Chardonet silk (denitrated) will sometimes give 500 mantles per kilogram at another time the kilogram makes 750 mantles of the same kind due to irregularity of thread. While some complaints as to these mantles are justified, it is said that another process is more perfect, and the problem of manufacture can be considered solved. Thousands of artificial silk mantles are exported from France and give satisfaction.

There are four establishments engaged in the manufacture of incandescent mantles in the Netherlands, the leading ones being at Amsterdam and Rotterdam. A small factory at Katwijk is engaged in the manufacture of thorium nitrate from monazite.

*Cerium Aluminum-Alloys.*—That aluminum may be greatly improved by alloying with it metallic cerium in small quantities has been shown by W. Borchers, of Aix-la-Chappelle, who has been granted a patent for

[1] *Daily Cons. and Tr. Reptg.*

the process.[1] The ductility of the metal is increased six or seven times and its resistance to snapping doubled by alloying with it 0.1 to 0.2 per cent. cerium. When the amount of cerium is up to 0.2 per cent. the texture of the metal is firmer and denser than with ordinary aluminum, and it will ring with a clear, bell-like tone. The alloy fills the finest moulded designs and is suitable for foundry work. It stands mechanical treatment well on account of its high ductility.

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[1] London *Min. Journ.*, July 6, 1912.

# NICKEL AND COBALT

The production of nickel in the United States is confined to one company, the International Nickel Company, which imports nickel matte from Canada for further treatment. During 1912 no nickel mining was carried on in the United States. The localities for nickel and cobalt in the United States, are Frederickstown, Mo., Webster, N. C., and the San Poil mining district of Washington. Some prospects also exist in Floyd and Roanoke Counties in Virginia. The Blackbird Creek in Idaho is said to contain ores containing high percentages of cobalt. The only nickel which may be said to be of domestic origin is obtained as a by-product in copper-refining. The total production by this source in 1911 is estimated at 445 tons of metallic nickel, but the greater part is probably of foreign origin. The production of electrolytic nickel during 1912 is believed to be much less than in 1911. The only explanation of this may be the larger amount of monel metal produced directly from the matte. The consumption of this metal is increasing. The mattes, as imported, contain about 80 per cent. of the combined metals, copper and nickel. Monel metal is composed of 58 per cent. nickel and 22 per cent. copper. As a by-product, electrolytic nickel is being produced by the Baltimore Copper Smelting & Rolling Company, the Raritan Copper Works, and the American Smelting & Refining Co., at its Maurer plant. Nickel sulphate is also produced by the United States Metals Refining Company.

The prices of nickel, according to large or small lots and the quality, were about from 40 to 45 cents per pound.

The International Nickel Company, declares a dividend of 8 per cent. on its common stock of $38,000,000. According to the report of the company, the project of enlarging the plant at Constable Hook, New Jersey, is in hand. The production is estimated at 32,000,000 lb. of nickel a year. In Canada, the subsidiaries are the Canadian Copper Company, which mines the ore and smelts it to matte and to oxide, and the Orford Company, which extracts the metals from these products. The Orford Copper Company also produces nickel sulphate and nickel ammonium sulphate, used for plating. The matte shipped to the United States is not all refined here, but some of it is re-exported for treatment in Europe. The International Nickel Co. also control the Nickel Corporation of Great Britain, and the Société Miniére Caledonienne of New

Caledonia. The Mond Nickel Company ships its matte to Swansea, Wales. The following table gives the imports and exports of nickel and cobalt for the United States in recent years:

| Year. | Imports. | | | | | | | Exports. | |
|---|---|---|---|---|---|---|---|---|---|
| | Nickel Ore and Matte. | | Nickel Alloys. (*a*) | | Nickel Mnfrs. | Cobalt Oxide. | | Nickel. (*b*) | |
| | Long Tons. | Value. | Pounds. | Value. | Value. | Pounds. | Value. | Pounds. | Value. |
| 899..... | 19,857 | $1,216,253 | (*c*) | ..... | ..... | 46,791 | $ 68,847 | 5,004,377 | $1,151,923 |
| 900..... | 25,670 | 1,183,884 | 455,188 | $139,786 | ..... | 54,073 | 88,651 | 5,869,906 | 1,382,727 |
| 901..... | 52,111 | 1,637,166 | 635,697 | 209,956 | $ 2,498 | 71,969 | 134,208 | 5,869,655 | 1,521,271 |
| 902..... | 14,817 | 1,156,372 | 752,630 | 251,149 | 30,128 | 79,984 | 151,115 | 3,228,607 | 925,579 |
| 903..... | 15,936 | 1,285,935 | 521,344 | 170,670 | 37,284 | 73,350 | 145,264 | 2,414,499 | 703,550 |
| 904..... | 8,548 | 915,470 | 589,555 | 203,071 | 2,950 | 42,352 | 86,925 | 7,519,206 | 2,130,933 |
| 905..... | 13,451 | 1,626,920 | 941,966 | 331,920 | 3,291 | 70,048 | 139,377 | 9,550,918 | 2,894,700 |
| 906..... | 15,156 | 1,816,631 | 210,000 | 77,373 | 8,963 | 41,084 | 83,167 | 10,620,410 | 3,493,643 |
| 907..... | (*d*)16,888 | 2,153,873 | 180,025 | 80,994 | 9,159 | 48,013 | 74,849 | 8,772,578 | 2,845,663 |
| 908..... | (*e*)16,322 | 2,396,217 | 241,868 | 91,388 | 10,010 | 219,098 | 17,077 | 9,770,248 | 3,297,988 |
| 909..... | (*f*)18,578 | 2,927,975 | 277,911 | 104,019 | 4,279 | 12,132 | 11,096 | 12,048,737 | 4,101,976 |
| 910..... | (*g*)28,519 | 4,085,076 | 323,239 | 125,013 | 14,759 | 6,124 | 4,806 | 15,244,937 | 4,704,088 |
| 911..... | (*h*)23,993 | 3,918,556 | 293,301 | 104,160 | ..... | 14,561 | 7,576 | 25,099,586 | 8,283,777 |
| 912..... | (*i*)33,101 | 5,638,456 | (*j*)223,168 | 103,300 | 17,203 | 31,848 | 15,132 | 28,815,016 | 8,515,332 |

(*a*) Includes nickel oxide, and alloys of any kind in which nickel is the material of chief value, in ingots, bars, and sheets. (*b*) Comprises domestic nickel, nickel oxide, and matte. (*c*) Not separately enumerated; included in "Nickel Ore and Matte." (*d*) Contained 18,418,305 lb. nickel; not reported previous to 1907. (*e*) Contained 16,586,423 lb. nickel. (*f*) Contained 21,916,182 lb. nickel. (*g*) Contained 32,050,032 lb. nickel. (*h*), contained 29,545,967 lb. nickel. (*i*) Contained 42,168,769 lb. nickel. (*j*) Weight of nickel alloys only, value $85,059.

The exports of nickel, nickel oxide and matte, from the United States in recent years, were as follows:

| | 1910. | | 1911. | | 1912. | |
|---|---|---|---|---|---|---|
| | Pounds. | Dollars. | Pounds. | Dollars. | Pounds. | Dollras |
| France..... | 1,493,873 | 490,050 | 5,463,358 | 1,955,700 | 5,083,947 | 1,886,200 |
| Netherlands..... | 7,720,323 | 2,449,300 | 9,101,150 | 2,835,465 | 7,387,447 | 2,315,400 |
| United Kingdom..... | 3,782,402 | 1,191,530 | 7.196,259 | 2,563,587 | 8,191,364 | 2,818,800 |
| Other countries..... | 2,248,338 | 573,208 | 3,338,819 | 929,025 | 5,152,258 | 1,494,932 |
| Total..... | 15,244,937 | 4,704,088 | 25,099,586 | 8,283,777 | 25,815,016 | 8,515,332 |

The imports of nickel alloys were 103,300 lb. valued at $85.059 in 1912. Additional imports were divided as follows: Oxides, $916; sheets and strips, $17,333; other manufacturers, $17,203. The imports of cobalt ore and zaffer, during 1912 were 759,394 lb. valued at $67,948. The cobalt oxide imported, dutiable at 25 cents a pound, amounted to 31,848 lb. valued at $15,132.

*Canada.*—The Sudbury Nickel District, is described by Professor A. P. Coleman.[1]

[1] Summary report of the mineral production of Canada, 1911, Department of Mines, Canada.

The Sudbury District, furnishes more than 60 per cent. of the world's nickel. The known deposits are all more or less connected with the basic edge of a great synclinal sheet of norite. A great fault has shifted and fractured the norite and green-stone, breaking them into irregular blocks, between which the ore has been deposited. The fault plane is nearly vertical.

The Canadian Copper Company increased the capacity of its matte smelting at Copper Cliff to about 2500 tons of ore per day. Most of the ore during 1912 came from the Creighton mine, which practically furnished one-half of the world's nickel. Some of the ore came from the Crean Hill and the Copper Cliff mines. Exploration of the old Frood mine No. 3, disclosed probably 50,000,000 tons of ore by diamond drilling, which has shown that this long outcrop of ore dips toward the basic edge of the norite. An ultimate capacity of 10,000 tons of ore per day is contemplated. The ore body in this mine is from 200 to 400 ft. thick and lies horizontally from 600 to 1000 ft. below the surface. The ore is a low grade compared with other ores of the district, and the combined nickel and copper is estimated at 3 1/2 per cent. Results of drilling at the Strathcona property, in Levack township, were not satisfactory. The auxiliary plant for Cobalt silver ores is to be discontinued.

The Mond Nickel Company has completed its 1000-ton ore smeltery at Coniston, about 4 miles east of Sudbury. Roast heaps are started at the new plant. The 300-ton smeltery at Victoria mines will be abandoned. The company obtains all its ores from the Victoria and the Garson mines. At the Victoria, which is the deepest mine in Ontario, an important extension of the ore-body on the 1600-ft. level was discovered. A 1000-ft. shaft is being sunk on the property next to the No. 3, of the Canadian Copper Co. The North Star mine is being reopened. A small amount of high-grade nickel ore from the Alexo mine, near Porcupine, Ont., was delivered at the Victoria plant in 1912.

The Dominion Nickel-Copper Company purchased the Murray mine from the H. H. Vivian estate, Swansea, Wales, and the Gertrude, Elsie and Victor mines from the Lake Superior Corporation, of Sault Ste. Marie, Ont. Drilling at the Murray is reported as having disclosed 4,000,000 tons of ore. A site has been selected for a treatment plant.

The American Smelting & Refining Company took several options in Levack township, and is now drilling.

Generally the Sudbury District has been more active in 1912 than in previous years, and the ore reserves have been considerab y increased. In a general way, the exploration began at the Trillabelle mine on the southwest end of the boat-shaped syncline, and was carried southwest

past the Chicago and Sultana mines to the Victoria. The Victoria mine is working upon two ore beds of comparatively small horizontal dimensions, but of astonishing continuity in depth. The basic edge of the norite can be followed from this point to the Crean-Hill, where copper ore prevails. Southwest of the Crean-Hill lies the rich Vermillion mine. Northeast of this point it may be said that for 6 miles no ore-bodies have been disclosed. The Creighton Mine is 1 1/2 miles further east, on a projection of norite from the northwest into the country rock. The Copper Cliff mine is on what is known as the Copper Cliff offset; a pipe-like ore-body is being worked a little to the north. The Garson mine is further to the northeast, 12 miles from Copper Cliff. On the Eastern Nickel Range with the Whistle mine at the north end, considerable drilling has disclosed new ore.

In the metallurgy, changes have been made as, for example, increasing the proportion of green ore to the roasted ore smelted, in the construction of a reverberatory furnace to treat fines and flue dust, and in the introduction of large basic lined converters. The scale of smelting operations also has been increased.

*New Caledonia.*[1]—The nickel ore exports from New Caledonia were as follows: 1911, 120.059 tons; 1912, 72,315 tons.

The nickel in first fusion matte exported amounted to 2933 tons in 1911, and 5097 tons in 1912.

The average values, as estimated by the Customs duty, were about 34 francs for the nickel ore, and 700 francs for the nickel matte. The average selling-price of nickel ore varies from 50 to 70 centimes the kilogram, which is a value free on board of 25 to 38 francs per ton of ore carrying 6 1/2 to 7 per cent. nickel.

The low exports of ore are noticeable, but to-day a part of the ore is treated for mattes containing 45 to 50 per cent. nickel, the exports of which, and the production, have nearly doubled in the last calendar year. What was exported in 1912 represents 36,000 tons of ore, so that the total figure is 108,000 tons.

There are about 800 nickel concessions in New Caledonia, of which 40 are being worked. A new law passed early in 1913 is to increase this proportion. The principal producers in 1911 and the production of each are as follows:

| | | |
|---|---|---|
| Société Le Nickel | T. | 47,000 |
| Baudoux and Metzdorf | T. | 16,000 |
| Vieux and Talon | T. | 17,750 |
| F. and G. Schmidt | T. | 10,780 |
| The Consolidated Mines | T. | 12,000 |
| Bouteiller and Suaud | T. | 10,500 |
| De Bechade | T. | 10,000 |
| L. Ballande | T. | 8,000 |

[1] G. du Poizat, "Echo Des Mines," April 10, 1913.

In 1911 the figure of ore for export, 120,000 tons, must have added to it 32,000 tons treated at the works at Doniambo, giving a total of 152,000 tons for comparison with 108,000 tons in 1912. This falling off can be explained by the heavy stocks existing in Europe after the heavy exportations and the exceptionally high freight rates in 1912. The progress in the last two years has certainly been greater than that of 1908 or 1909, for example.

The increased consumption of the metal may be estimated to-day at 25,000 tons, whereas in 1901 it was 10,400 tons, and in 1908 15,000 tons.

Oxide or cobalt is no longer produced, and the principal cobaltiferous concessions have been abandoned. The reason for this is that the ores of the Cobalt district in Canada are produced in quantities larger than the demand for this product throughout the world. The price fell from 28 francs in 1907 to 9 francs the kilogram in 1912.

Many difficulties have been overcome in smelting the nickel in New Caledonia. The works at Thio (Société Le Nickel) produce the matte in a cupola furnace of 100 tons, capacity, capable of treating 30,000 tons in a year. The works at Havre are reserved for refining. A similar installation may be made where the matte is now being produced.

At the works of Point Doniambo (Société des Hauts Fourneaux de Noumea), 36,000 tons of 5 to 6 per cent. nickel ore were treated in 1912. The works at Tao, with their hydro-clectric installation, have tried some interesting electric furnace experiments. The three works which have exported pure matte are as follows:

| | Kg. Matte. | Kg. Nickel. |
|---|---|---|
| Société des Hauts-Fourneaux de Noumea | 3,367,058 | 1,515,176 |
| Société le Nickel | 1,625,600 | 731,520 |
| Société de Tao | 105,166 | 52,583 |
| Total | | 2,299,279 |

The matte produced by the first two works requires three operations in order to refine it in Europe; the ferro-nickel produced by the Tao Works requires but one operation before being used in final form in Europe. The value of the 5000 tons of nickel matte exported in 1912 is estimated at 3,500,000 francs.

The Société Le Chrome has the intention of building a hydroelectric plant of 15,000 h.p., on the Bay of Yaté, for the manufacture of ferro-chrome and ferro-nickel. The hydroelectric installation is not yet completed.

*Norway.*—The nickel production in Norway has increased regularly. In 1912 at the Flaa mines, about 24,000 tons of ore were produced.

At the Foes mines nickel ore to the extent of 5500 tons was produced. The pyrrhotite ore from Evje, in Saetersdalen, Southern Norway, contains about 2 per cent. nickel. These productions, together with 3000 tons imported from Greece, were shipped to the nickel smelting works at Evje, where matte was produced and shipped to the new refinery of Christiansand. At this plant the Hybinette process was started, and during 1912 about 400 tons of pure nickel and 200 tons of pure copper were produced. In the first business year, it is said that a disbursement of 10 per cent. dividend was made by the works at Christiansand.

In 1909, the Evje works treated 5770 metric tons of ore, carrying 1.1 per cent. Ni. Each 100 tons of ore gave 2.77 tons of matte, carrying about 40 per cent. Ni and 25 per cent. Cu. This matte is refined at the Christiansand electrolytic refinery.

The matte is said to be used as anode in a feebly acid solution, from which pure copper is deposited. When the nickel in the bath reaches a certain limit, the current is cut off, and the small amount of copper remaining is thrown out by sulphuretted hydrogen. The iron is also precipitated at this point, but no information is given as to how this is done. The nickel solution is then heated and nickel deposited, using insoluble anodes. The current consumption is said to be large, so that the success of the process depends on a cheap supply of power, such as is to be had in Norway.

In the seventies the Ringerike Nickel Works was among the greatest Norwegian producers of nickel, but the New Caledonia ores began to be marketed and finally the plant shut down. The ore at the Ringerike is also a pyrrhotite.

*Other Countries.*—According to a Consular Report, the exports from Antwerp, Belgium, to the United States, of metallic nickel, during 1911, were $187,507, and during 1912, $408,823. Belgium also exported to the Netherlands in 1910 56 tons of metallic nickel. The value of the nickel which went to the Netherlands in 1910 was $2,370,000. Germany imports annually about 15,000 tons of nickel ore; in 1911, 14,897 tons; in 1912, 14,987 tons. The nickel imported in 1912 was 2027 tons; that exported was 1672 tons.

In Greece in 1909, garnierite was discovered at Thebes and Lokris. The ore contained 4 to 5 1/2 per cent. nickel, and altogether 24,000 tons of ore were exported.

The United Kingdom imported oxide of nickel, 17,297 cwt. valued at $419,249 in 1910; 15,117 cwt. valued at $36,639 in 1911, and 23,679

cwt. valued $568,500 in 1912. The value of the nickel declared through the port of Swansea, Wales, and exported to the United States, was $1698 in 1911. The nickel salts and sulphate were valued at $7411 in 1910 and $20,040 in 1911.

The copper nickel deposits in Insizwa, Mount Ayliff, East Griqualand, Africa, are described by A. L. Du Toit.[1] This is of interest as it is only in the last few years that systematic prospecting has been carried out. The average nickel contents from 14 specimens of ore are stated as 3.8 per cent. nickel, and the copper contents at 4.1 per cent.

## Cobalt

The largest producers of cobalt are the ores of the Temiskaming district, Ontario, Canada. The fairly high-grade conglomerate ore of Cobalt has the following analysis:[2]

Iron, 6.45 per cent.; S, 1.15 per cent.; As, 3.4 per cent.; Sb, 1 per cent.; Co, 1.02 per cent.; Ni, 0.87 per cent.; Bi, 0.05 per cent.; Cu, 0.14 per cent.; Silver, 287 oz. per ton. In the last few years the production of cobaltiferous ores far exceeds what is necessary to furnish the cobalt oxide consumed in the arts. The world's production is estimated at only about 350 tons of oxide annually. The price has been cut in half in the past few years, and no new uses have been developed. At present the principal use is in making pottery and glass. The cobalt ores are partly manufactured into oxide in Canada, and partly in England or by the Orford Copper Company of Constable Hook, New York. The cobalt oxide exported from Trenton, Ont., to the United States during 1912, was valued $7437.

The use of cobalt for an alloy with chromium was started recently, but it is not known that large quantities have been manufactured. This alloy, known as stellite, can be used for knives and utensils and promises to be an outlet for the production. Cobalt is also used in the manufacture of artists' colors. The trade of cobalt oxide is closely controlled. The price during 1912 was 80 cents per pound; 90 cents per pound is to be maintained for 1913. No statistics of the production are available, and while there is some recovery from Cobalt district ores, this would be much increased if the uses of cobalt were wider. There is no production of the metal as a by-product of copper refining, and no payment is made for the contents in the ore. It is reported that 3,000,000 lb. of cobalt-nickel residues are stored at the American refineries, treating cobalt ores.

[1] Annual Report of the Geol. Commission, Cape of Good Hope, Dept. of Mines, 1910.
[2] C. L. Hargrave, *Eng. and Min. Journ.*, June 8, 1912.

The cobalt oxide imported into Japan in 1910 was 24,424 lb. valued $24,500; mostly from Great Britain.

The crude copper from the one furnace in operation in the Belgian Congo[1] in 1912 is sold at Antwerp and contained about 6 per cent. cobalt. In 1911 the copper analyzed 90 per cent. copper, 5 1/2 per cent. cobalt, 0.3 per cent. iron and 0.5 to 1 per cent. sulphur. Later shipments owing to better scorification assayed 95.5 per cent. copper, 1.8 per cent. cobalt, 0.86 per cent. iron, 1.1 per cent. sulphur. What is sold early in 1913 contains 95.15 per cent. copper, 3.1 per cent. cobalt, 0.74 per cent. iron and 76 per cent. sulphur, and no precious metals.

*Treatment of Cobalt Ores.*—In the amalgamating cyaniding process used at the Nipissing high-grade mill[2] the cake of pulp after washing on the filters contains the unaltered cobalt and nickel arsenides. For the first seven months of 1912, the assay was 9 per cent. cobalt and 4.5 per cent. nickel. Some of the last year's product contained as per analysis of Johnson & Sons: Nickel, 9.72 per cent.; cobalt, 5.85 per cent.; iron, 2.58 per cent.; antimony, 3.80 per cent.; bismuth, 0.09 per cent.; copper, 0.06 per cent.; tellurium, 1.39 per cent.; arsenic, 29.50 per cent.; sulphur, 1.59 per cent.; silica, 11.44 per cent.; lime, 8.63 per cent.; magnesia, 2.91 per cent.; carbonic acid, 13.55 per cent.; combined water, 5.44 per cent.; balance, 3.45 per cent.

The only product marketed at the Nipissing works is the silver; 6 to 7 tons of the residue are produced per day.

The general practice is to smelt in a blast furnace producing most of the silver in base bullion and a speiss which is roasted and treated in the wet way for cobalt, nickel and silver. The smelting plant is complicated. The ore is difficult to sample.

*Cobalt in Paints as Dryer.*—The cobalt compounds generally offered in the market to-day are of two classes: the first cobaltous oxide, acetate, sulphate, chloride, nitrate, hydroxide, and basic carbonate and the second, resinates, both fused and precipitated, oleates and their combinations. The first are used in the manufacture of the second by varnish makers. It is only in the past year[3] that cobalt driers have been offered to the American manufacturers of paints. The price prohibits their general use, which is not thoroughly understood, and experiments are not carried further on this account.

The cobaltous compounds can be worked as driers like those of manganese, zinc, lead, etc., but as organic compounds are not efficient driers. The cobaltic combinations are very active driers, however, and the con-

[1] Sydney H. Ball, *Min. and Sci. Press*, Apr. 19, 1913; *Min. and Sci. Press*, Jan. 20, 1912.
[2] R. B. Watson, *Eng. and Min., Journ.*, Dec. 7, 1912.
[3] V. P. Krause, Long Island City, N. Y., *Eighth Int. Cong. Appl. Chem.*

version into these is accomplished in a number of ways, by air or oxidizing agents added to the cobaltous driers.

When lead, manganese and metallic driers are well chosen, raw linseed oil can be made to dry by the addition of from 5 to 10 per cent. or even less, the time of drying under average weather being 10 to 24 hours. By using cobalt driers 1 to 3 per cent. of a liquid drier is used. It is believed that the ultimate action of cobalt driers upon paint films is not as harmful as are some of the manganese lead compounds.

The method of making the resinate, oleates, etc., from the cobalt salts, is described by Mr. Krauss. Some of the chemical manufacturers offer cobalt acetate with directions for its use as a drier. Between 2 and 0.4 of one per cent. are necessary to dry linseed oil.

*Cobalt-Aluminium Alloys.*—Experiments made by Dr. Borchers and Dr. Schirrmeister, show that the addition of tungsten or molybdenum will make the grain very much finer and the tensile strength nearly three times that of pure aluminium. Alloys richer in cobalt have a higher tensile strength, but are adapted best for foundry and not for rolling purposes. The composition varies between these limits: 0.8 to 1.2 per cent. tungsten; 8 to 10 per cent. cobalt; balance, aluminium.

*Acid-resisting Alloys of Nickel.*—The development of an acid-resisting alloy was described by Prof. S. W. Parr, University of Ill.[1] A preliminary study of alloys gave the following amounts dissolved in an arbitrary strength (25 per cent.) $HNO_3$.

| | Per cent. |
|---|---|
| Pure iron | 100.0 |
| Commercial Al | 51.4 |
| Monel metal | 19.2 |
| Nichrome (Ni 90 Cr 10) | 7.9 |
| Copper Al (Cu 90 Al 10) | 3.5 |
| Nickel chrome Al | 1.3 |
| Ferro-silicon | 0.1 |

The Ni, Cu, Cr alloys gave the following amounts dissolved:

| Ni | Cu | Cr | Per cent. |
|---|---|---|---|
| 65 | 30 | 5 | 100.00 |
| 80 | 10 | 10 | 1.25 |
| 80 | 5 | 10 | 0.02 |
| 80 | 5 | 15 | 0.05 |
| 75 | 5 | 20 | 0.013 |
| 70 | 10 | 20 | 0.023 |

The large per cent. of copper that can be employed between limits without affecting the solubility is remarkable. The last alloy was chosen for final experiments; it was modified by additions for securing sound castings free from blowholes, but the matter requires further study. The shrinkage is very large. The composition of the average range of the final alloy obtained by addition of Al, etc., is Ni, 66.6; Cr, 18; Cu, 8.5; W, 3.3; Al, 2; Mu, 1; Ti, 0.2; B, 2; Si, 2. The solubility with $H_2SO_4$

[1] *Eighth Intl. Cong. Appl. Chem.*

is as a rule less than with $HNO_3$, but the HCl solubility is greater and requires further tests. The practical use of this alloy in a bomb calorimeter is described by Dr. R. H. Jesse, Jr.[1]

*Nickel and Iron Alloys.*—That nickel easily forms an alloy with iron is well known. The uses of nickel iron alloys have, however, been limited because of the impurities with the nickel, it being difficult to obtain it in a pure state. Nickel steels are two times as hard as welded iron, and are less easily fractured than ordinary steel, the tensile strength 55 tons per square inch. Alloys of iron and nickel containing less than 23 per cent. of the latter are non-magnetic. Another property used in electrical apparatus is the high resistance of alloys containing more than 30 per cent. nickel. The coefficient of expansion when 45 per cent. nickel is contained in the alloy is only one-twentieth that of steel.

*Extraction of Copper from Nickel Ores.*—The following ore was calcined by Mr. Wedge[2] in December, 1909: Cu, 1.85 per cent.; Ni, 2.75; Fe, 47.78; S, 30.85; $SiO_2$, 15.30 per cent. It was desired to extract the copper leaving the nickel in the ore with the iron. The sulfatization resulted as follows: Water-soluble copper, 69.2; water-soluble nickel, 13.6; acid-soluble copper, 12.8; acid-soluble nickel, 4.4; total-soluble 100. The analysis of the leached calcine is as follows: Copper, 0.29 per cent.; nickel, 2.80 per cent.

*Nickel Extraction from Garnierite.*—The extraction of nickel[3] from garnierite ($H_2$(Ni, Mg) $SiO_4$+*aq.*) is taken up in French patent No. 441,074, by P. A. M. de Mehereng. The finely crushed ore is roasted in a reverberatory, and then boiled for two hours with a 1 to 5 per cent. solution of sulphuric acid. The solution is then treated with powdered chalk, precipitating all metals but nickel and magnesia. The nickel is then precipitated by sodium carbonate.

*Wells' Nickel Extraction Process.*—A recent patent of Horace L. Wells, of New Haven, Conn. (U. S. pat. 1,044,316), provides for the extraction of nickel from nickel-copper matte by means of hydrochloric acid. The matte is pulverized to 60-mesh, or finer, and treated twice with 18 to 25 per cent. hydrochloric acid at a temperature between 110 and 212° F. The acid used in the second treatment is available for use as the first leach in treating a succeeding batch of nickel matte. The matte is agitated during this treatment. The solution is treated for nickel or for nickel salt. The manufacture of nickel salt from this solution is covered by U. S. pat. No. 1,039,861, issued to H. L. Wells, of New Haven. The solution is treated with sulphuretted hydrogen to precipitate copper, and an oxidizing agent, such as black oxide of nickel,

[1] *Eighth Intl. Cong. Appl. Chem.*
[2] Utley Wedge, *Eighth Intl. Cong. Appl. Chem.*
[3] *Eng. and Min. Journ.*, Oct. 26, 1912.

is added and the iron is precipitated in any suitable manner (for example, by adding calcium carbonate); sufficient sulphuric acid is then added to react with the chloride present, and sufficient ammonium sulphate to form nickel ammonium sulphate, which is recovered in the crystallized state. The mother-liquor may be utilized in dissolving fresh matte.

*Borchers-Pedersen Nickel Process.*—In this process (U. S. patent 1,043,291), the ore is smelted, a high silicate slag being produced. The ore obtained is roasted, converting the iron into oxide and sulphurizing the copper and the nickel. The leaching is done with a combined sulphurous and sulphuric-acid solution, obtained by passing water over towers through which the escaping restricted gases pass. Frequently precipitation of the solution is carried on by either sodium or calcium sulphide. The copper is thrown out in acid solution, and finally the nickel by adding more alkaline-earth sulphide. The residues after leaching are returned to the smelting operation. In the present process only 80 to 90 per cent. of the copper and nickel in the matte are recovered, the balance being returned to the smelting operation.

*Treatment of Nickel-copper Mattes.*—A wet process of treating nickel-copper mattes that have been blown free of iron is patented by McKechnie and Beasley (Brit. pat. 15,850, of July 8, 1911). They are heated with sulphuric acid in a closed vessel to a temperature exceeding 100° C., at a high pressure. The nickel sulphide is dissolved and the liberated hydrogen sulphide, under the high pressure, precipitates any copper from solution. The solution contains all the nickel free from copper. If roasting the matte leaves insufficient nickel sulphide to cause the precipitation of all the copper, additional matte, preferably unroasted, is introduced.

*Electroplating Heavy Nickel Deposits.*—The question of obtaining thick deposits of nickel has been investigated by A. Holland.[1] One bath suggested consisted of crystallized sulphate nickel, 40 grm.; boric acid, 6 grm.; water to make up 400 c.c., using a 0.3 amp. current on a 42-sq. cm. cathode, gave no hydrogen at the cathode. The best results were obtained with nickel-fluoborate solutions. The bath is difficult to prepare. The mixture suggested is 250 grm. of water; 130 grm. of boric acid, to which after cooling is added 285 grm. of 45 per cent. commercial hydrofluoric acid; to this the carbonate of nickel is added. When no more gas is evolved, the mixture is stirred until a uniform milk of nickel carbonate is obtained. After shaking this mixture is filtered and washed, to make up two liters. Even with this carefully prepared bath it takes three or four days of plating, using a cast-nickel anode, for the best results.

[1] *Bull. Soc. d'Encouragement pour l'Ind. Nat.*, July, 1912.

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# NITROGEN FIXATION

By E. F. Roeber

Since the publication of the full review of the subject of fixation of atmospheric nitrogen in the Mineral Industry, Vol. XIX (1910, p. 59) and the additional notes in Vol. XX (1911, p. 554) the various industries in which atmospheric nitrogen is utilized for the production of useful compounds has made decisive and, in some cases, rapid progress.

*Nitric Acid and Nitrates.*—The Norwegian industry employing the Birkeland-Eyde flaming arc-disk process was the subject of a lecture by Samuel Eyde,[1] before the Eighth International Congress of Applied Chemistry, held in New York in 1912. This Norwegian industry is in a flourishing condition. The Germans, represented by the Badische Company, which had been working in conjunction with the Eyde interests, have withdrawn from Norway and have taken up the Haber ammonia process (see below).

The Southern Electrochemical Company, with works at Nitrolee, South Carolina (the only American company employing a process for the production of nitric acid and nitrates by electric arc discharges through air) is still experimenting on a comparatively large scale, according to the latest first-hand information, and no technical details are yet available.

*Calcium Cyanamide.*—While the various calcium cyanamide factories in different parts of the world are doing well and the American Cyanamide Company is enlarging its works considerably, an interesting new proposal for the use of calcium cyanamide has been made by a new British corporation, the Nitrogen Products and Carbide Company, Ltd. They intend to use the cyanamide first for the production of ammonia, $CaCN_2 + 3H_2O = CaCO_3 + 2NH_3$. While this has been proposed and done before in European factories, ammonium sulphate being the final product, the British corporation mentioned above intends to work up the ammonia into nitric acid by the Ostwald contact process.[2] If successful this method will bring the cyanamide

[1] Complete and profusely illustrated in *Trans. Eighth Inter. Cong. of Appl. Chem.*, Vol. XXVIII, p. 169. Slightly abstracted without illustrations, in *Met. and Chem. Eng.*, Vol. X, p. 617. (Sept. 12, 1912). A new design of absorption towers is described in an article by Rudolf Heins in *Met. and Chem. Eng.*, June, 1913., (Vol. XI, p. 359).

[2] *Iron and Coal Trades Review* (London), May 23, 1913; *Met. and Chem. Eng.*, August, 1913, Vol. XI, p. 438.

manufacture into competition with the interests making nitric acid from nitrogen oxides produced by electric arc discharges through air. The outcome of this proposal will be watched with decided interest.

*Ammonia.*—The most important event of the year 1912 was the announcement that the Haber process for the production of ammonia from its elements nitrogen and hydrogen had been solved fully on a manufacturing scale and that the first factory of the Badische Company for synthetic ammonia was being erected at Oppau, near Ludwigshafen-on-Rhine, Germany. This announcement was made by H. A. Bernthsen in a lecture at the Eighth International Congress of Applied Chemistry.[1]

*Nitrides.*—The old idea of accomplishing the fixation of atmospheric nitrogen by means of nitrides has reached a new and decisively interesting stage by the development of the Serpek process[2] on a large experimental stage in France. The principle of the Serpek process is, first, the production of aluminium nitride, AlN, from a mixture of alumina and carbon in an electrically heated kiln in an atmosphere of nitrogen or producer gas ($Al_2O_3+3C+N_2=2AlN+3CO$, the temperature being between 1600 and 2000° C.), followed by the decomposition of the aluminium nitride by water or caustic soda solution, thereby liberating the nitrogen as ammonia and producing an alkaline aluminate solution from which pure alumina can be obtained ($2AlN+3H_2O=2NH_3+Al_2O_3$).

The original intention was to use the alumina obtained for the production of fresh aluminium nitride, so that the process would be cyclic with respect to alumina, and the net result would be the production of ammonia. (By addition of the above two equations representing the two steps, the net result is: $3C+N_2+3H_2O=3CO+2NH_3$). However, it has been found that the production of aluminium nitride does not work well with pure alumina. Apparently the impurities in the raw alumina act beneficially as catalysers.

The intention is now to produce simultaneously pure alumina and ammonia (in the proportions of $Al_2O_3$ to $2NH_3$) and to use the pure alumina for the production of aluminium. The amount of ammonia that can be produced by the process will, therefore, be restricted by the amount of alumina which can be used for aluminium production.

[1] Transactions Eighth International Congress of Applied Chemistry; *Met. and Chem. Eng.*, Sept. 12, 1913 (Vol. X, p. 637). The original report of Professor Haber, which led the Badische Company to develop the Haber process on a large scale, has been published in the *Zeit. f. Electrochem.*, Jan. 15, 1913 (Vol. XIX, p. 53) and translated in abstract in *Met. and Chem. Eng.*, April, 1913 (Vol. XI, p. 211 The report by Haber contains in full the laboratory experiments. Bernthsen's paper also contains interesting information on the development of the process on a large scale.

[2] S. A. Tucker and H. L. Read, Transactions American Electrochemical Society, Vol. XXII, p.57 (1912), abstracted in *Met. and Chem. Eng.*, Nov., 1912 (Vol. X, p. 745); J. W. Richards, *Met. and Chem. Eng.*, March, 1913 (Vol. XI, p. 137) and May, 1913 (p. 281); S. A. Tucker, *Met. and Chem. Eng.*, March 1913 (Vol. XI, p. 139); W. Fraenkel, *Zeit. f. Electrochem.*, April 15, 1913 (Vol. XIX, p. 362.)

According to the best first-hand information, the Serpek process, though promising, is still in the experimental stage.

A useful summary of literature on the utilization of atmospheric nitrogen (covering proposals and accomplishments, unsuccessful and successful processes) is given by Thomas H. Norton in a pamphlet on Utilization of Atmospheric Nitrogen (Department of Commerce and Labor, Special Agents Series, No. 52)

# PETROLEUM AND NATURAL GAS

The output of petroleum in the United States during 1912 exceeded by 7,000,000 bbl. the amount produced in 1911. This increase was coincident with a rising scale of prices, particularly on the lighter oils, whereby exploration of new fields was stimulated. Exploration of relatively new districts was rewarded with success notably in the Electra field in northern Texas, in the Blue Creek pool in West Virginia, and in the Salt Creek field in Central Wyoming. In the old producing districts, attempts to enlarge the boundaries of the fields were, in the main, unfruitful, except in California where the Midway field was much extended and accounted for most of the increase noted in that state.

Among other countries, Russia, Roumania and India registered normal increases in output, while production in Galicia and the Dutch East Indies diminished slightly. The most noteworthy event was the great expansion in the output of Mexico, which more than doubled that of 1911.

The price of crude oil throughout the world advanced rapidly during 1912 by reason of increasing consumption, to supply which, stocks accumulated during previous years were heavily depleted. The probable explanation of the price movement is the active demand for the lighter derivatives.

PRODUCTION OF CRUDE PETROLEUM IN THE UNITED STATES.
(In barrels of 42 gal.)

| Field. | 1906 | 1907 | 1908 | 1909 | 1910 | 1911 | 1912 |
|---|---|---|---|---|---|---|---|
| California (a) | 30,538,000 | 40,085,000 | 45,000,000 | 58,250,300 | 74,327,150 | 77,224,359 | 84,530,364 |
| Colorado | 600,000 | 400,000 | 411,836 | (b) 310,771 | (b) 239,794 | (b) 226,926 | (b) 206,052 |
| Gulf { Texas | 12,666,000 | 12,350,000 | 11,206,464 | 9,256,000 | 8,181,580 | 8,845,396 | 11,778,324 |
| Gulf { Louisiana | 7,100,000 | 4,620,000 | 6,835,130 | 3,220,000 | (b) 6,841,395 | 10,720,420 | 9,791,896 |
| Illinois | 4,900,000 | 24,540,024 | 33,685,106 | 30,898,339 | (b)33,143,362 | (b) 31,317,038 | (b)28,601,308 |
| Lima { Indiana. } Ohio. | 25,680,000 | 8,030,000 | 7,287,000 | 6,192,000 | 5,171,000 | 4,656,000 | (e) 5,454,510 |
| Mid-Continental(c) | 21,929,905 | 47,556,906 | 48,274,782 | 48,007,267 | 53,613,030 | 57,911,525 | 52,771,600 |
| Ky.-Tennessee | 1,000,000 | 1,250,000 | 1,250,000 | (b) 639,016 | (b) 468,774 | 472,458 | (b) 484, 368 |
| Pennsylvania (d) | 27,345,600 | 25,500,000 | 24,240,000 | 25,394,200 | 26,089,900 | 22,275,000 | 25,325,538 |
| Wyoming | 13,000 | 13,000 | (e) 13,000 | (b) 22,137 | (b) 115,430 | (b) 186,695 | (b) 1,572,306 |
| Others | 4,000 | 3,000 | (e) 3,000 | (e) 5,000 | (e) 5,000 | (e) 5,000 | *Nil.* |
| Total | 131,771,505 | 164,347,930 | 178,203,345 | 182,205,030 | 208,196,415 | 213,840,817 | 220,516,266 |

(a) Reported by the California Producers' Association, except the statistics for 1907 and subsequent years, which are of our own collection. (b) Statistics of the U. S. Geological Survey. (c) Kansas and Oklahoma. Includes production from North Texas, in 1910. (d) Pennsylvania, New York, West Virginia, Eastern Ohio. (e) Estimated.

EXPORTS OF MINERAL OILS FROM THE UNITED STATES. (a)
(In Thousands of Gallons and Thousands of Dollars.)

| Year. | Crude Petroleum. | | Naphthas. | | Illuminating. | | Lubricating. | | Residuum. | | Totals. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1898 | 120,436 | $5,016 | 17,258 | $1,071 | 764,823 | $38,895 | 65,526 | $7,626 | (b)30,436 | $815 | 998,479 | $53,423 |
| 1899 | 117,690 | 5,958 | 18,210 | 1,597 | 733,382 | 49,172 | 71,116 | 8,658 | (b)21,609 | 658 | 962,007 | 66,043 |
| 1900 | 133,161 | 7,341 | 18,570 | 1,681 | 739,163 | 54,693 | 71,211 | 9,933 | (b)19,750 | 845 | 986,855 | 74,493 |
| 1901 | 127,008 | 6,038 | 21,685 | 1,742 | 827,479 | 53,491 | 75,306 | 10,260 | (b)27,596 | 1,255 | 1,079,059 | 72,786 |
| 1902 | 145,234 | 6,331 | 19,683 | 1,393 | 778,801 | 49,079 | 82,200 | 10,872 | (b)38,316 | 922 | 1,064,234 | 68,597 |
| 1903 | 126,512 | 6,782 | 12,973 | 1,519 | 691,837 | 51,356 | 95,622 | 12,690 | (b) 9,753 | 282 | 936,697 | 72,629 |
| 1904 | 111,176 | 6,351 | 24,989 | 2,322 | 761,358 | 58,384 | 89,738 | 12,389 | 34,904 | 1,174 | 1,022,165 | 80,620 |
| 1905 | 126,185 | 6,086 | 28,420 | 2,215 | 881,450 | 54,901 | 113,730 | 14,312 | 70,728 | 2,128 | 1,220,513 | 79,641 |
| 1906 | 148,045 | 7,731 | 27,545 | 2,488 | 878,274 | 54,858 | 151,269 | 18,690 | 64,645 | 1,971 | 1,269,788 | 85,738 |
| 1907 | 126,306 | 6,334 | 34,625 | 3,676 | 905,924 | 59,635 | 152,029 | 19,210 | 75,775 | 2,528 | 1,294,660 | 91,383 |
| 1908 | 149,190 | 6,520 | 43,890 | 4,542 | 1,129,005 | 75,988 | 147,769 | 18,971 | 77,552 | 2,793 | 1,547,405 | 108,815 |
| 1909 | 170,338 | 6,028 | 68,759 | 5,800 | 1,046,401 | 67,814 | 161,640 | 20,016 | 121,966 | 4,180 | 1,569,103 | 103,839 |
| 1910 | 180,111 | 5,404 | 100,695 | 8,407 | 940,247 | 55,642 | 163,832 | 20,921 | 117,605 | 3,732 | 1,502,491 | 94,107 |
| 1911 | 201,843 | 6,165 | 137 295 | 11,483 | 1,112,295 | 61,055 | 183,320 | 23,337 | 133,979 | 3,882 | 1,768,732 | 105,923 |
| 1912 | 188,711 | 6,770 | 186,000 | 20,459 | 1,026,138 | 62,084 | 216,393 | 28,297 | 266,237 | 6,599 | 1,883,480 | 124,210 |

(a) In addition to the above, the following quantities of paraffin and paraffin wax were exported (1=1000); 1898, 166,317 lb. ($6,363); 1899, 181,861 lb. ($7,650); 1900, 157,108 lb. ($8,186); 1901, 151,695 lb. ($7,960); 1902, 175,268 lb. ($8,398); 1903, 204,120 lb. ($9,596); 1904, 174,582 lb. ($8,273); 1905, 160,836 lb. ($7,873); 1906, 173,504 lb. ($8,463); 1907, 207,504 lb. ($10,209); 1908, 141,667 lb. ($6,923); 1909, 181,328 lb. ($7,609); 1910, 199,913 lb. ($7,329); 1911, 214,018 lb. ($7,048); 1912, 294,591 lb. ($9,603). (b) Reported in 1,000 bbl. of 42 gal.

Imports of crude oil into the United States during 1912 amounted to 290,280,000 gal. ($4,677,174) as compared with 61,377,550 gal. ($1,888,-410) in 1911. Imports of refined products (mainly benzine) were19, 486,-050 gal. ($1,356,057) in 1912, against 7,641,750 gal. ($518,168) in 1911. Both crude oil and refined products are admitted free of duty.

## Petroleum in the United States

*Appalachian Field* (By Frederick G. Clapp.)—The year 1912 was one of the most profitable in many of the eastern fields, which include the states of Pennsylvania, New York, West Virginia and southeastern Ohio, also known as the Appalachian field.

West Virginia.—This prosperity was due largely to the Blue Creek pool in Elk district, Kanawha County, W. Va., the first well in which was drilled in September, 1911. Operations were started in this pool by the Ohio Fuel Oil Co. and were pushed rapidly by that company, as well as by the South Penn Oil Co., the W. S. Edwards Oil Co., the United Fuel Gas Co., the United Fuel Oil Co., by Davidson & Gates and some other producers. At one time this pool produced 18,000 bbl. of Pennsylvania grade oil per day, and a single well produced over 300 bbl. the first hour; but during the latter half of 1912 the production decreased. The Blue Creek pool was one of the largest in the history of West Virginia and the best in the eastern field for 20 years; it is of particular interest on account of being situated in a county which had practically been condemned by

dry holes and which was believed by most practical oil men to lie "too far east." The oil has come mostly from the Squaw sand at a depth of about 1800 ft. The fact that the Blue Creek pool and the old Shinnston pool are both situated in the same geographical belt, in a portion of West Virginia that had been practically given up as unproductive, has stimulated drilling, so that wildcatting has been going on the past season in districts which were never before looked upon as promising. Judging by a number of showings which are being developed in new localities, the end of discoveries in West Virginia has not been reached.

Another interesting pool at present is on Falling Rock Creek, in Big Sandy district, Kanawha County, W. Va. A number of wells have been drilled there in the last few years, and in October, 1912, a 100-bbl. producer was drilled. In the same month a well of 600-bbl. initial production was obtained, but it declined rapidly. The sand in the Falling Rock field is the Berea grit. Roane County also attracted some attention in 1912, and at present the Scafford Run pool, in Spencer district of that county, appears promising. The Berea is the productive sand. The Carter Oil Co., the Fisher Oil Co. and the South Penn Oil Co. were active in that vicinity.

Ohio.—Next to West Virginia in importance among the eastern states is Ohio, where the Wooster oil pool has been opened in Wayne County, the Reading township pool in Perry County, and the Armstrongs Mills pool in Belmont County. The first two of these pools mentioned are a part of the Clinton sand field or Central Ohio field, which parallels the Central Ohio gas belt on the east. This gas field, extending from Hocking County northward to Lake Erie and beneath the lake to Canada, is one of the most extensive and productive in the world; being bordered on the east by many important oil pools, a few of which have already been opened.

The Bremen and Junction City pools declined in 1912, while the Straitsville-Gore pool increased in area and production, becoming the most active oil development in Ohio. The Reading township pool is in reality an extension of the Junction City pool to the north; and like several other recently discovered pools, is surrounded by dry holes. The Reading township discovery is an example of what may be expected in central Ohio, when development is conducted systematically at favorable localities. As in the Bremen and Straitsville-Gore pools, the oil is of Pennsylvania grade. This is the first year that much excitement has existed north of Bremen and Junction City.

One of the most interesting localities is just south of the city of Wooster. This pool was discovered in 1911 by the Columbia Fuel Co. while prospecting for gas, and this company and the Ohio Oil Co. control the entire

territory and operations. For this reason the growth of the Wooster pool has not been so spectacular as where more competition exists; but the production is increasing, and the pool appears to be of considerable size. The producing sand is the Clinton. The price of oil, however, is less than that of Pennsylvania and Bremen grades, being only $1.43 late in 1912, the pipe lines having made a special rate for Wooster oil, classifying it between the Pennsylvania and Corning grades.

The New Straitsville field has the distinction of being one of the deepest oil fields ever developed in the East; and in that field a completed well, if set to pumping, costs about $9000. Operations in the New Straitsville-Gore field were pushed rapidly by the Chartiers Oil Co., Kachelmacher & Co. and by various smaller concerns. Wells of large volume have been frequent, and at times the production of this pool was above 3000 bbl. per day. Many wells in these villages have been drilled on town lots.

Another interesting locality in 1912 was in Muskingum, Coshocton and Licking Counties, where several companies have prospected for some time past, with the result that during the latter half of 1911 and in 1912 a number of good wells were drilled, which will open at least three new pools. The Gratiot-Black Hand pool was discovered in September, 1911, by the Columbus Gas & Fuel Co. at the south end and by the Everett Gas Co. at the north end. The Planet Oil Co. also has some good wells in this belt. In trying to discover other pools in the vicinity, however, many disappointments have been experienced by the operator.

Several miles north of the Black Hand field the Arkansas Fuel Oil Co. has two good wells in Licking County, and this pool may connect with several small producers owned by the Ohio-Rochester Oil & Gas Co. in the vicinity. In Pike township, Coshocton County, the Ohio-Rochester Co. has several wells of small volume in what is known as the Norris pool. Efforts to find oil in quantity in other parts of Coshocton and Muskingum Counties proved unavailing, but showings have been found, and conditions are such that pools are believed to exist at several localities. The same is true of several other localities in north-central Ohio, where the geological structure is favorable. It is not commonly realized that the Clinton sand of Ohio is continuous northward with sand of the same name in Canada, where it is also productive. This is one of the most productive and persistent oil and gas sands in the country.

SUMMARY OF OPERATIONS IN OHIO FOR 1912.

| Month. | Wells completed. | New Production (bbl. daily). | Dry Holes | Daily Average Runs (bbl.). | Gross Stocks at Close of Month Bbl. |
|---|---|---|---|---|---|
| ıry..... | 333 | 4,674 | 121 | 58,374 | 13,455,640 |
| ıary..... | 286 | 11,166 | 80 | 66,792 | 13,083,288 |
| h..... | 397 | 11,805 | 122 | 77,413 | 12,491,170 |
| ..... | 471 | 19,416 | 128 | 82,514 | 11,658,625 |
| ..... | 546 | 23,584 | 142 | 85,106 | 11,620,775 |
| ..... | 613 | 23,675 | 142 | 83,906 | 11,320,615 |
| ..... | 631 | 16,942 | 153 | 83,080 | 10,908,167 |
| st..... | 706 | 11,130 | 190 | 83,314 | 11,315,925 |
| mber..... | 741 | 10,481 | 235 | 75,127 | 11,248,198 |
| ber..... | 688 | 7,829 | 247 | 76,775 | 10,616,324 |
| mber..... | 643 | 5,391 | 173 | 70,834 | 10,340,681 |
| nber..... | 532 | 7,044 | 99 | 73,558 | 10,422,467 |
| als..... | 6587 | ..... | 1832 | 76,402 | ..... |

Pennsylvania.—The Canonsburg pool, which looked promising and several gushers at the beginning of 1912, failed to equal expectas, and later in 1912 the majority of its completed holes were failures. s field was a town-lot development and suffered from all the usual of wisdom in such developments. The Perrysville pool, in Alleıy County, likewise proved a disappointment, only a few wells of ing size being obtained.

ecently the possibility of finding production in unknown deep sands he east has attracted several companies into drilling expensive test s, and at present several of these in New York, Pennsylvania and t Virginia have exceeded 5000 ft. in depth.

n encouraging feature of 1912 for oil producers was the increasing and for the light grades of oil, under the influence of which the price Pennsylvania oil was advanced from $1.35 at the beginning of the to $2 at the end of November. As might be expected, the increase rice has stimulated development, and has particularly increased the k of the wildcatter. Hence, we may expect a number of new pools e found in 1913. The prices paid for oil of various grades by the -line companies on Dec. 26, 1912, and also the increase in price ng 1912 is shown in the accompanying table:

PRICES PAID FOR OIL OF VARIOUS GRADES IN 1912.

| Grade. | Increase since Feb. 1. | Price Dec. 26. |
|---|---|---|
| lyvania..... | 55 cents. | $2.00 |
| r black..... | 48 cents. | 1.53 |
| Castle..... | 51 cents. | 1.53 |
| la..... | 22 cents. | 1.53 |
| ng..... | 55 cents. | 1.50 |
| l..... | 38 cents. | 1.50 |
| ter..... | 41 cents. | 1.43 |
| Lima..... | 28 cents. | 1.22 |
| Lima..... | 28 cents. | 1.17 |
| na..... | 28 cents. | 1.17 |
| rset..... | 32 cents. | 1.15 |
| ston..... | 26 cents. | 1.05 |
| nd..... | 17 cents. | 0.65 |

*California* (By M. L. Requa).—The most interesting features of the California oil industry in 1912 were those relating to the financial phase. During the year the dissolution of the Standard Oil Co. was accomplished, and the Standard Oil Co. of California assumed ownership of all its California property. The result has been apparently in no way harmful to the Standard Oil Co. and in no way beneficial to the producer of oil. The Standard Oil Co. of California still continues to be the dominating factor, with its refineries at Point Richmond and at El Segundo.

During 1912, negotiations for the sale of the Union Oil Co. to the General Petroleum Co. were conducted, resulting, in November, in the payment on account of $500,000, the price named in the agreement being $130 per share, less certain commissions. The purchaser has two years in which to pay the price for the properties. This sale will be beneficial to the oil industry of California as it will place the Union Oil Co. and the Independent Agency producers upon a stronger financial basis than they have heretofore enjoyed. Within a year, the General Petroleum Co. has stepped into a rank of first importance in California. It finished construction of a pipe-line from the Midway field to Los Angeles and has entered the market for oil to transport through this line in addition to its own. It has chartered four tank steamers, and arranged for the construction of six more. It has two 20,000-bbl. refineries under construction, and is vigorously developing its holdings in the light-oil fields in the Lost Hills and elsewhere. A gusher of 30-deg. oil was recently brought in on the company's land.

The disposal of the holdings of the Southern Pacific R. R. in the Associated is still a matter of doubt. Apparently the Standard Oil Co. does not desire to acquire this interest, and the only possible purchasers at this time would seem to be the General Petroleum Co. or the California Petroleum Co. which has been recently organized and has taken over the holdings of E. L. Doheny in California.

A three-cornered combination of the Standard Oil Co., the General Petroleum Co. and the California Petroleum Co., would be the greatest blessing that has yet come to the oil producers of the state, as it would mean a definite settlement of the question of marketing concerns for all time.

No marked change occurred during 1912 in the fields of the state. Midway continued to dominate the situation as heretofore. Much territory to the north and northwest was added to the field during the year. The estimated production of the various fields is as follows:

The oil used for fuel in the fields is not included in the totals for 1911 and 1912. This amounts to about 3,000,000 bbl., making the state's gross total about 87,500,000 bbl. in 1912. The surplus oil on Jan. 1, 1913,

was 47,659,155 bbl. The surplus for 1912 was 6,452,309 bbl. No new fields were developed and some territory that was looked upon with favor proved disappointing.

CALIFORNIA PETROLEUM OUTPUT. (a)
(In barrels.)

| District. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|
| Belridge | ..... | ..... | ..... | 1,351,817 |
| Coalinga | 15,406,600 | 18,597,301 | 17,793,221 | 18,803,292 |
| Coyote | ..... | ..... | (b) | 1,351,827 |
| Fullerton(c) | 4,309,000 | 5,085,844 | 5,887,069 | 5,787,765 |
| Kern River | 14,508,292 | 14,725,096 | 12,225,273 | 10,878,606 |
| Los Angeles | 529,965 | 465,799 | 436,200 | 386,362 |
| Lost Hills | ..... | ..... | 63,500 | 1,245,777 |
| McKittrick | 5,807,212 | 5,480,631 | 5,339,364 | 4,785,907 |
| Midway | 2,234,456 | 11,168,839 | 20,821,669 | 25,199,198 |
| Newhall(d) | 516,778 | 653,923 | 139,508 | 116,244 |
| Salt Lake | 3,821,233 | 3,247,507 | 2,815,097 | 2,668,125 |
| Santa Maria | 8,080,488 | 7,592,637 | 6,259,766 | 5,326,261 |
| Summerland | 66,300 | 75,050 | 64,875 | 52,200 |
| Sunset | 1,999,800 | 9,149,159 | 4,468,087 | 5,264,552 |
| Ventura | ..... | ..... | 453,764 | 653,234 |
| Watsonville(e) | 63,799 | 36,490 | ..... | ..... |
| Whittier | 848,800 | 1,197,351 | 1,106,966 | 715,369 |
| Total | 58,192,723 | 77,475,627 | (f) 77,224,359 | 84,530,364 |
| Consumed as fuel at wells | ..... | (g) 4,000,000 | (h) 5,200,000 | (h) 3,000,000 |

(a) As estimated by the California Oil Producers Association. (b) Included with Whittier. (c) Includes Brea Cañon. (d) Includes Santa Paula. (e) Includes Sargents. (f) After deducting an estimate of 650,000 bbl. to cover loss and overestimates. (g) In 1910, this amount is included in the total production. (h) Not included in the total.

There was a movement in the last months of 1912 looking to the erection of topping plants by the producers of light-gravity oil and the selling of these tops. One of the results of this was a notice from the Standard Oil Co. that it would receive no oil so treated. The action of the Standard Oil Co., in notifying the producers of heavy-gravity oil that their contracts would not be renewed, created great consternation among the producers of heavy oil. That this action was logical is fairly plain. The Standard Oil Co. had in storage large reserves of heavy-gravity oil, and is now apparently able to secure all the oil it needs of lighter gravity. It therefore has no need to buy heavy-gravity oil. Companies affected by this ruling associated themselves with a view of taking some definite action for the disposal of their product. A number of such concerns joined the Independent Producer's agency, while others closed down their operations; during December, 1147 heavy-oil wells were shut down for this reason.

The gas line from Midway to Los Angeles was completed to the borders of Los Angeles but it is not yet in operation. This gas is to be sold wholesale to the Los Angeles Gas and Electric Co., and is to be retailed by them.

The new pipe-line of the General Petroleum Co. from Midway to Los

Angeles went into operation early in the spring of 1913. The new line of the Producers Transportation Co. from Junction to Port Harford is nearing completion. This is an 8-in. line and when completed will give one complete line from Midway to Port Harford and one complete line from Coalinga to Port Harford.

The Standard made a move to erect a refinery at Bakersfield with the probable intention of taking the asphaltum out of its heavier Kern River oils. This will both lighten the gravity of its oils, and give it asphaltum in the San Joaquin Valley which can be sold to be used in connection with the State highway or shipped to Eastern points. Since the advent of the Standard into the asphaltum business the price has dropped on San Francisco Bay from $14 to about $10. At these figures there is no money in the business except under conditions identical to those under which the Standard Oil is manufacturing and selling.

Taken as a whole the oil business of the state marked time during 1912 in an endeavor to readjust itself because of the developments in Midway. While the improvement in prices that was hoped for did not occur, the situation is gradually righting itself, and the next 12 to 18 months ought to put the business upon a sane, stable, and profitable basis. There is no reason to expect lower prices and every reason to expect prices to advance.

The prices of California oils at the beginning and end of 1912 were as follows:

| | | |
|---|---|---|
| Coalinga, light | $0.60 | $0.65 |
| Coalinga, heavy | 0.30 | 0.35 |
| Kern County, light | 0.60 | 0.65 |
| Kern County, heavy | 0.30 | 0.35 |
| Santa Maria, light | 0.70 | 0.70 |
| Santa Maria, heavy | 0.40 | 0.40 |
| Los Angeles, light | 1.00 | 1.00 |
| Los Angeles, heavy | 0.70 | 0.70 |
| Fullerton and Whittier light | 1.00 | 1.00 |
| Fullerton and Whittier heavy | 0.70 | 0.70 |

To assure an independent supply of fuel for the oil-burning ships of the navy, the Federal Government established two reserves of oil land in California in 1912. The first, announced in September, involved 39,000 acres in the Elk hills, and the second covered 29,541 acres in the Buena Vista hills, both in Kern County. The latter tract is in the Midway field, and a number of private operators have been working there; these will be ousted unless they can prove prior claim. The main government station will probably be located at Port San Luis, with others at San Francisco, San Diego, and other ports.

*Colorado.*—The two leading fields are the Boulder and the Florence, the latter being much the larger. Active prospecting has been con-

lucted in Routt, Rio Blanco, Jackson, Montezuma and Mesa Counties, nd in the San Luis Valley, but oil has been found only in the three first-nentioned localities. Late in 1912, strong flows of gas were developed n the vicinity of De Beque, New Castle and Rifle, in Garfield County, ut no commercial quantity of oil. In the Boulder and Florence fields, 7 oil wells were flowing on Jan. 1, 1912; 21 wells were drilled during the ear, of which 13 were dry, and 8 yielded oil or gas; 9 wells were aban-loned in 1912, leaving 76 in operation at the end of the year. The yield f crude oil in 1912 was 214,572 bbl. ($187,737) compared with 247,055 bl. ($224,769) in 1911.

*Illinois* (By Raymond S. Blatchley).—Illinois began in 1912 the nevitable decline in oil production that comes to a thoroughly developed il territory. The production for the year was 28,601,308 bbl., as against 1,317,038 in 1911. The decline can be checked only by the development f new fields along the western side of the Illinois basin and the northward xtension of the La Salle anticline, along which the main fields lie.

The decline of production is further marked by the drain on storage which has accumulated since 1906, and reached its highest amount about Sept. 1, 1910, with 29,289,164 bbl. From that date to Aug. 1, 1912, the rate f withdrawal from reserved oil averaged 19,500 bbl. per day. Since hat time the rate of discharge is about 30,000 bbl. daily, or about one ank per day. At this rate the reserve oil will be exhausted within a year.

Peculiar economic conditions which prevailed in 1912 and the demand or motor products caused a steady advance in price of Illinois oils, until

FLUCTUATION IN PRICES, PER BBL., OF ILLINOIS OIL IN 1912.

| Date. | Above 30° B. | Below 30° B. | Date. | Above 30° B. | Below 30° B. |
|---|---|---|---|---|---|
| an. 1 | $0.67 | $0.57 | Sept. 10 | 0.87 | 0.84 |
| an. 2 | 0.70 | 0.60 | Oct. 25 | 0.90 | 0.87 |
| an. 6 | 0.72 | 0.62 | Nov. 7 | 0.92 | 0.89 |
| an. 25 | 0.75 | 0.65 | Nov. 15 | 0.94 | 0.91 |
| eb. 3 | 0.78 | 0.68 | Nov. 25 | 0.96 | 0.93 |
| lar. 4 | 0.81 | 0.71 | Dec. 2 | 0.99 | 0.96 |
| pr. 24 | 0.83 | 0.73 | Dec. 9 | 1.02 | 0.99 |
| lay 24 | 0.85 | 0.75 | Dec. 16 | 1.05 | 1.02 |
| une 13 | 0.85 | 0.77 | Dec. 20 | 1.05 | 1.05 |
| une 27 | $0.85 | $0.79 | Dec. 31 | 1.05 | ..... |
| uly 25 | 0.87 | 0.82 | | | |

he grading of oil and price according to difference in specific gravity was liminated on Dec. 20, 1912. The extensive increase in prices caused the ighest annual value of oil in the history of Illinois.

The Clark, Cumberland, Coles and Edgar County fields (shallow oil territory) remained steady in production during 1912. The wells of this area produced from one to four barrels per day, which was considered

profitable where a number of them were pumped on one power. The total daily yield was about 7000 bbl. Several wells were drilled in this area in 1912 to a depth of about 2500 ft., where small quantities of a high-grade sour oil were found.

The Lawrence County field, with its seven producing sands, still upheld its remarkable yield and did much to retard the decline of general production. Much new drilling was done to the McClosky limestone at a depth of about 1850 and 1650 ft. respectively, in the southern and northern ends of the field. Several large wells were reported with initial productions from 400 to 2000 bbl. Many of the older wells in the same section were redrilled to this sand.

A new field was tapped in August, 1912, about two miles northwest of Allendale, in Wabash County. The oil was found at a depth of about 1480 ft. and seemed to be governed by an isolated shelf along the western limb of the La Salle anticline. The field is about 1 1/2 miles long and 3/4 mile wide. The gravity of the oil is about 37° B. On Jan. 1, 1913 there were 24 wells, yielding about 838 bbl. daily. The initial production of the Allendale wells ranged from 50 to 800 bbl., but the wells declined in yield rapidly until the average is about 36 bbl. Many dry holes were drilled, even in the midst of promising territory.

The Carlyle and Sandoval fields declined rapidly in their yield and assumed a steady low production similar to the Clark and Crawford County areas. Several new wells were drilled in the Carlinville pool, making a total of five gas wells and four light-oil wells. The gas is utilized in Carlinville. There are also four gas wells, of 2 1/2 million cu. ft. capacity each, lying 1 mile south of Greenville, in Bond County. The Bond County Gas Co. supplies Greenville with abundant gas.

SIX-YEAR RECORD OF ILLINOIS OIL WELLS.

| Years. | Wells Completed. | Wells Producing. | Initial Output, Bbl. | Dry Holes. | Average Yield per Well, Bbl. | Total Production, Bbl. |
|---|---|---|---|---|---|---|
| 1906..... | 3283 | 2793 | 113,012 | 490 | 40.4 | 4,397,050 |
| 1907..... | 4988 | 4260 | 139,163 | 728 | 32.6 | 24,281,973 |
| 1908..... | 3574 | 3019 | 78,960 | 555 | 26.1 | 33,686,238 |
| 1909..... | 3151 | 2593 | 89,756 | 558[1] | 34.0 | 30,898,339 |
| 1910..... | 2139 | 1671 | 93,256 | 468 | 55.8 | 33,143,362 |
| 1911..... | 1364 | 1059 | 66,919 | 305 | 63.1 | 31,317,038 |
| 1912..... | 1256 | 986 | 65,686 | 270 | 66.6 | 28,400,000 |

[1] 70 gas wells included.

On Jan. 1, 1912, it was estimated that 19,982 wells had been drilled in Illinois. Of these, 3152, or 15.7 per cent., were barren. In 1912, 1256 wells were drilled, with 270, or 21.4 per cent., barren. The total up to Jan. 1, 1913, was 21,238 wells drilled, with 3422, or 11.4 per cent., barren.

*Louisiana* (By Holland S. Reavis).—Louisiana's production of crude petroleum in 1912 was 9,791,896 bbl., a decline of over 900,000 bbl. as compared to the state's 1911 yield, which was 10,720,420 bbl. Included in the 1912 figures, as given, is the yield of a few wells in Marion County, Tex., across the line and a few miles distant from the Caddo field in northwestern Louisiana, so that the decrease in the state's output is really even larger than appears from a comparison of the totals as stated.

The Caddo district, including Marion County, Tex., produced 7,188,514 bbl. in 1912 as against 6,995,826 bbl. in 1911—the 1911 total not taking into account the Marion County, Tex., output. It may be seen, therefore, that Caddo fell behind its 1911 yield. A unique feature of operations in this district was the completion of some good oil wells in the bed of Ferry Lake put down by the Gulf Refining Co.

Two or three gas wells were completed in and near Shreveport and oil in small quantities was developed in some deep tests south of Shreveport in De Soto and adjoining parishes.

Vinton, in the coastal region of Louisiana, just east of the Texas line, is credited with 1,333,163 bbl. in 1912, as against 2,454,103 bbl. in 1911. The productive area of this field is limited, but recent developments show the presence of a prolific sand below the formation which has heretofore furnished the pool's output. The new deep sand, found at from 2200 to 2400 ft., may repeat the history of the Jennings, La., pool, where 20,000-bbl. wells were completed in formations underlying the sands which supplied the field's production during the first two years of its development. Late in December the Gulf Refining Co., of Louisiana, brought in a gusher in the Vinton deep sand which started at 14,400 bbl. a day. Jennings produced 1,167,219 bbl. in 1912 as compared to 1,180,177 bbl. in 1911. The limits of the Jennings field were not extended.

In February, 1912, a well was completed at Pine Prairie, in Evangeline Parish, La., which flowed for several days at the rate of 1000 bbl. per day. This was in new territory and gave promise of developing an important pool. Later, after the well had been shut in and reopened, it made large quantities of water. A number of tests drilled in the same territory failed to get oil in paying quantities, and the first well is therefore classed as a "freak." The location is close to a mound of rock salt.

Prices advanced materially in Louisiana during the year. On Jan. 1, 1912, Caddo light oil was quoted at 62 cents per bbl. at the wells and Caddo heavy oil at 40 cents. At the close of the year Caddo light was 91 cents and heavy 60 cents. Contracts for the year were made at Jennings Jan. 1, 1912, at 65 cents and were renewed Jan. 1, 1913, at $1

for oil at the wells. Vinton contract prices advanced from 60 cents to 90 cents during the year.

*Ohio* (By J. A. Bownocker).—The petroleum industry in Ohio during 1912 was without notable incident. Some drilling is still being done in the Trenton limestone field of Northwestern Ohio but without satisfactory results. The limits of this field were determined many years ago, and though great efforts have been made to extend them, the results have not been favorable. With the outlines of the territory established, efforts were made to find oil at greater depths in the Trenton, and often with good results. Still more recently tests have been made to find oil below the Trenton but the failure was complete. In a well drilled near Findlay in 1912, gneiss was struck at a depth of 2755 ft., this being the first time the entire sedimentary series has been penetrated in this State.

In the "Clinton" sand of Central Ohio no large discoveries have been made. Near New Straitsville, in the southern part of Perry County, about 50 wells were drilled. Of these, 15 were dry and 35 yielded oil, the largest starting at perhaps 300 bbl. per day. Farther west, in the vicinity of Gore, Hocking County, about 60 tests have been made, and 50 of these yielded oil, the largest producer starting at 150 bbl. per day. The sand in this pool is found at about 2800 ft.; it is deeper in the vicinity of New Straitsville. Farther north, in Perry County, fairly productive wells have been drilled in the vicinity of New Lexington, but efforts farther east in the county have been less successful. Several tests were made in Muskingum County, with but little success. Three wells are reported from Coshocton County, all of which yield oil, but the largest started at only 15 bbl. per day, and so can scarcely be rated successful.

In Perry and Hopewell townships, in the eastern part of Licking County, more than 20 wells were drilled in 1912, the depth averaging about 3000 ft. Seven of the tests were failures and the largest of the producing wells started at approximately 100 bbl. per day. Farther north in the State little success has been met. A few producing wells have been drilled in the vicinity of Wooster, Wayne County, but their small size, when considered with their depth and the occasional dry hole, makes drilling a hazardous proposition. Still farther north in Cuyahoga County, quite a number of wells have been sunk, but the results have not justified the labor and expense. Altogether, the prospect of oil from the "Clinton" sand in Ohio is not very encouraging.

In the Carboniferous sands of southeastern Ohio there has been but little change. Drilling in this part of Ohio began in 1860 and has been in progress ever since, and quite actively since 1890. Wells by the thousands have been sunk and the prospects for new pools are very

mall. Like the Trenton limestone territory, the production is diminishng each year.

In the natural gas industry the year 1912 was unusually quiet. The ne important field is the Central Ohio, where the "Clinton" sand is ie source of the fuel. During recent years the territory has been exnded along its extreme southern end in Hocking County. Some of ie wells have been large and one had an initial flow of about 6,000,000 1. ft. per 24 hours. The Ashland County field has been quite largely xtended, especially to the southwest where it has entered Richland ounty. The Lodi field in Medina County has also been enlarged, but rther north there have been but few additions. Efforts to extend eastard the central part of the field have met with but little success, and it highly probable that the field has now reached or is past its zenith and rapid decrease in production is more than a possibility.

*Texas* (By Holland S. Reavis).—Texas produced 11,778,324 bbl. of rude petroleum in 1912, making a gain of over 2,000,000 bbl. over the 911 record, which was 8,845,396 bbl. The increase came entirely from he new light-oil territory in the Electra district, Wichita County, situted in the northern part of the state, a few miles south of Red River. 'his field, first developed in April, 1911, is credited with 4,647,180 bbl. 1 1912, as compared to 899,579 bbl. in 1911. The older coastal disricts of Texas produced 6,551,220 bbl. in 1912, as against 7,275,281 bl. in 1911, practically all heavy oil; Powell, in Navarro County, prouced 301,143 bbl. of heavy oil, as compared to 373,055 bbl. in 1911; 'orsicana, in Navarro County, produced 105,333 bbl. of light oil, as ompared to 128,526 bbl. in 1911, and Petrolia, in Clay County, east f Electra, produced 173,448 bbl., as compared to 168,965 bbl. in 1911.

While the production of heavy crude in the state declined from ,648,336 bbl. in 1911 to 6,852,363 bbl. in 1912, the output of light crude ose from 1,197,060 bbl. in 1911 to 4,925,961 bbl. in 1912.

The most interesting oil development in Texas in 1912 was in Wichita nd Clay Counties, in the northern part of the state. Electra, in Wichita 'ounty, was the scene of continuous activity throughout the year, with n average of from 60 to 70 drilling rigs constantly in operation. On an. 1, 1912, the daily average production of this field was 11,242 bbl.; year later it was 15,050 bbl. The average daily yield per well on an. 1, 1912, was 208 bbl., and on Dec. 31, 1912, it was about 51 bbl. 'he lowest average daily production, 8441 bbl., was in March, and the ighest, 16,150 bbl., in November.

At the beginning of the year the proved area of the field was estimated t 820 acres. At its close it covered about eight sections, or more than 000 acres, lying in an east and west strip, in length about three times

its width. The important extensions were mainly in a due east course from the original Putnam lease of the Corsicana Petroleum Co., although, during the year, the deep sand (1900 ft.) on the Waggoner and Bywaters leases, was opened up and proved to be the most consistent and profitable producing formation of the field.

During the first 5 months of 1912 the district was without pipeline transportation, and all the production, except that handled in tank cars, was run into steel storage. Stocks on Jan. 1, 1912, were 373,500 bbl.; on July 15, the maximum figure, 1,360,000 bbl., was reached, since which there has been a steady decrease to 1,044,000 bbl., the present storage figure. During the latter part of April, the Texas company began delivering oil to Henrietta through a 6-in. line, which, 1 month later, was completed and in operation through to the company's Dallas refinery. The Magnolia Petroleum Co.'s 8-in. line to Corsicana and Beaumont, with a capacity of 15,000 bbl. per day, was put in operation throughout its entire length early in August. This line is about 450 miles long.

The gas field, at Petrolia, has furnished several 25 to 30 million-foot wells, all located, however, in the vicinity of the earlier development. In April a new deep oil sand was discovered about a mile southwest of the town by the Developers' Oil & Gas Co., the first deep well since the completion of the J. M. Guffey Petroleum Co.'s No. 1, Dunn. It started flowing about 100 bbl. per day and later pumped that amount with great regularity for some time. By the end of the year the drilling had shown that this oil sand was local and relatively unimportant.

The first excitement of 1912 was precipitated on March 14, when the Miller well, in Archer County, 40 miles due south of Wichita Falls, developed an oil sand at 950 ft. The well was shut down before the sand was drilled through, and several days later, about 25 bbl. of black, 37° oil was baled out. In the development which followed, none of the dozen or more tests drilled in the vicinity showed more than a trace of oil, and nearly all were drilled to 2000 ft. or deeper. The locality is now abandoned.

The second surprise came in July, when the Corsicana Petroleum Co. finished a 75-bbl. flowing well southwest of Burkburnett, in Wichita County, and about 18 miles northwest of Wichita Falls. The well appeared normal in every respect, with plenty of gas, and oil not dissimilar to that at Petrolia. The sand was about 15 ft. thick, and was found at 1835 ft. At the end of the year the district had about 20 drilling wells and five producing, with a total yield of about 450 bbl. In August, the Eeds well was brought in, 5 miles due east of the nearest production in the Electra field. It, too, flowed with good gas pressure from a 1440-ft. sand, making about 150 bbl. per day, and its production has held up steadily; yet at least 5 tests drilled in its immediate vicinity, com-

pletely surrounding it, have all failed to strike oil. In all the wildcatting in the northern part of the state, except that near Red River, the results have been largely negative. At the very close of the year, a 3,000,000-ft. gasser, about 1050 ft. deep, was finished in the northwest corner of Shackleford County, about 30 miles northwest of the two gas wells at Moran, in the same county.

In south Texas there were no important extensions of producing territory in the coastal fields. Several wells were completed in the 3000-ft. sand north of the Humble district, and near the San Jacinto River. One of these, drilled by the Sun company, started at 1200 to 1400 bbl., and is still a good pumper.

In line with the general advance in crude-oil prices, the Texas market strengthened appreciably during the year. In north Texas the price of light oil at the wells on Jan. 1, 1912, was 55 cents, and heavy oil, 50 cents. On Dec. 31, 1912, light oil was 88 cents, and heavy, 70 cents. Contracts were made Jan. 1, 1912, in the coastal fields for periods of 12 to 18 months, at 72 and 72 1/2 cents per bbl. for heavy oil at the wells. Some of these contracts were renewed Jan. 1, 1913, at $1 to $1.07 7/8 per bbl. at the wells. South Texas crude oil sold on Jan. 1, 1912, at 70 cents per bbl., on board cars, for fuel use. A year later the price was $1.10 to $1.20 per bbl., on board cars.

Pipe-line construction in Texas during 1912 was as follows. An 8-in. line, 449 miles long, was laid by the Magnolia Petroleum Co. between Electra and Beaumont, connecting at the latter point with the same company's lines leading to deep water at Sabine, on the gulf coast. Through the new line the Magnolia Company supplies crude to its refineries at Corsicana, about midway between Electra and the terminus, and at Beaumont. There are five stations, the distances between them being as follows: Electra to Alvord, 94 miles; Alvord to Corsicana, 117 miles; Corsicana to Richards, 120 miles; Richards to Beaumont, 118 miles. De La Vergne crude-oil engines furnish the power at the stations for pumping the oil. The line traverses the various oil fields of North Texas.

The Gulf Pipe Line Co. constructed a 6-in. branch line from its main 8-in. Oklahoma-Texas trunk line at Saltillo to Fort Worth, a distance of 136 miles, for the purpose of furnishing crude to the Gulf Refining Co.'s new refinery at Fort Worth, which was completed and placed in operation in the spring of 1912. The Pierce Fordyce Oil Association completed a refinery at Fort Worth in the spring of 1912, obtaining its crude supply by tank cars from Electra and Oklahoma, and also receiving oil from the pipe line of another company, which passes through Fort Worth. The Texas Company constructed an 8-in. pipe line from the North Texas oil fields to Dallas, by way of Fort Worth.

*West Virginia* (By I. C. White).—The output of petroleum was increased two million barrels or more over the production of 1911 by the continued development and expansion of the Blue Creek field in Kanawha County, where gusher wells were found in the Squaw sand horizon. The Lucas pool, opposite Shinnston, Harrison County, also added some gushers from the Fourth Sand horizon in the latter half of 1912 to help swell the total for the year.

In natural gas, West Virginia still easily retains it primacy, producing for the market nearly half as much as all the other states of the Union, in spite of an enormous waste which still continues, mostly from her oil wells. Some of this gas escaping with the oil is now being partially utilized, however, at compressing stations scattered through the oil fields, in which large quantities of gasoline are manufactured; West Virginia stands at the head of the list of states in the extraction of gasoline from natural gas.

During the year a very prolific new pool of Berea sand oil was struck on Scaffold Run, only a few miles from Spencer, Roane County, as the direct result of predictions made in the West Virginia Geological Survey Report on Roane County, by Ray V. Hennen, Assistant Geologist.

*Wyoming* (By L. G. Huntley).—Production was confined chiefly to the Salt Creek and Shannon pools, north of Casper, in Natrona County. In this field the two principal producing companies were hampered by insufficient storage and refinery capacity. The Midwest Oil Co. nearly completed an addition to its refinery at Casper, and early in 1913 was handling 8000 bbl. of crude per day. The other refinery, that of the Northern Pipe Line & Refining Co., has a capacity of 3000 bbl. per day. Both are working to capacity night and day, and both had wells in the Salt Creek field, which were closed in for lack of storage capacity. About 125 bbl. per day of heavy lubricating oil came from the Shannon field, just north of the main Salt Creek production. The oil from the Salt Creek field, after the naphtha and illuminating-oil constituents were taken off, was sold to the railroads for fuel.

The small production in the vicinity of Cody, in Park County, and in the northern part of Big Horn County, was not increased, and was consumed locally. A refinery at Cowley handled about 125 bbl. of crude oil per day from four wells at Cody. The production from the Dallas field, south of Lander, combined with that from the Plunkett pool to the north, amounted to about 130 bbl. per day, which was taken by the Chicago & North-Western Ry.

Great activity prevailed in the Salt Creek field, but the uncertainty regarding the Government's attitude as to the withdrawn lands hindered development and Eastern operators were chary of entering the state.

Another handicap to operation in the state was inadequacy of transportation facilities, and their high cost. At present the rate by wagon from Casper to the Salt Creek field—a distance of about 45 miles—is 75 cents per 100 lb. The railroad under construction from Powder River station to Thermopolis, and connecting through the Burlington, to Boise, Idaho, will open up large tracts of favorable oil territory.

The Salt Creek oil field is in Natrona County, central Wyoming, about 45 miles north of Casper. A commercial and geological description of the district is given by T. E. Jamison, State Geologist of Wyoming, in *Bull.* 4, Series B. Of the different fields in the district, the greatest development has taken place in the Salt Creek dome and Shannon fields; while the Dugout Creek district and the Bothwell syncline are comparatively unexplored; the Teapot dome is withdrawn from entry. About twelve companies are operating in the district. In the Shannon district forty wells have been driven, three of which are dry, four produce water only, and thirty-three produce oil. In the Salt Creek dome, 81 wells have been driven, the production per well varying from a few barrels to as much as 2000 bbl. per day. The oil is 39° to 42° B. and has paraffine base. Its constituents are 17 per cent. gasolene, 30 per cent. kerosene, 53 per cent. lubricating, paraffine and coke. Several formations carrying oil are known, but the most productive are the Wall Creek sandstone and the Shannon sandstone. The total production of the Salt Creek district to date is estimated at about 2,500,000 bbl. The average daily production is only 7500 bbl. on account of a lack of refinery capacity, although the wells are capable of producing 12,000 bbl. The oil is transported through the pipe-lines of the Midwest Oil Co. and the Natrona Pipe-line & Refinery Co. to their refineries in Casper.

*Midcontinental Field* (By E. Haworth).—The production of oil during 1912 in the Midcontinental field was not so great as for either of the two preceding years. Rising prices, however, stimulated development so that the total number of wells drilled was almost as large as for any year in the history of the field. The year began with crude at 46 cents per bbl. This was increased gradually throughout the entire year, usually by an advance of 2 cents at a time. The last advance was made about the middle of November, which lifted the price to 83 cents per bbl. As the production was uniform month by month, and the advance in price likewise uniform, the average price for the year was from 64 cents to 66 cents per barrel.

Development in Kansas and Oklahoma was confined almost entirely to working in and around the old pools with considerable wildcatting in a general westward direction. This resulted in the discovery of a new pool of oil near Cushing, substantially midway between Tulsa and

Oklahoma City. Also, the fields around Ponca City increased their production materially so that at times as much as 1000 bbl. per day were shipped. The greatest activity in development was confined to the Electra field. Here many new oil wells were found and the interest was active and leases high in price.

No new purchasing companies of consequence entered the field during 1912. The Prairie Oil & Gas Co. was again the largest buyer, taking a little over 30,000,000 bbl. As its deliveries were 33,500,000 bbl., its stocks were reduced from 41,512,202 bbl. to 38,734,838 bbl. at the end of the year. The next largest buyers were the Texas Oil Co., and the Gulf Oil & Pipeline Co. These two companies bought substantially the same amount of oil each year. The independent refineries increased their purchases. The extra price in oil seems to have stimulated all of them.

The price of fuel oil advanced rapidly as crude went up. In the early part of the year the Standard Oil Co. at Kansas City declined to make yearly contracts for the supply of fuel oil. Many consumers resorted to coal, so that the total consumption of fuel oil throughout Kansas was much less than usual. It is generally understood that with the beginning of 1913, time contracts may be made for fuel oil at reasonable rates, considering the price of crude.

OIL PRODUCTION, MID-CONTINENT FIELD.
(Kansas and Oklahoma. In barrels.)

| | 1909. (a) | 1910. (a) | 1911. | 1912. |
|---|---|---|---|---|
| Prairie Oil and Gas Company | 28,773,727 | 31,597,313 | 34,691,298 | 30,727,848 |
| Texas Oil Company | 7,329,500 | 7,513,000 | 8,934,800 | 8,488,064 |
| Gulf Oil and Pipe Line Company | 6,728,490 | 7,941,500 | 8,669,827 | 8,333,366 |
| Independent refineries | 5,175,550 | 6,387,500 | 5,365,600 | 5,097,325 |
| Fuel oil, crude | ..... | ..... | 250,000 | 125,000 |
| Total | 48,007,267 | 53,429,313 | 57,911,525 | 52,771,603 |

(a) From *Oil, Paint and Drug Reporter.*

The gas situation grew steadily worse throughout the year. Kansas City and other cities to the north of the fields did not have nearly so much gas as desired during the winter of 1911–12. Numerous cases of litigation were started, the most of which were settled by compromise. The Kansas Natural Gas Co. was bound by contracts to furnish gas for manufacturing purposes at low prices. In a number of instances the parties holding such contracts mandamused the company to compel it to furnish a sufficient supply of gas and the same procedure was followed by a number of cities and towns. During all this time the company was active in a search for new supply, hoping thereby to offset the constant decline in the older fields, particularly in the Hogshooter pool.

Unfortunately, no new gas pools of note were discovered in 1912. The closest approach is a small pool lying to the east of the Glenn Oil pool. Throughout this part of Oklahoma the rocks dip gradually to the west, so that the strata rise to the east from the oil pool. Just on the eastern border of the oil pool a number of strong gas wells were obtained, some of them reaching a capacity of 35,000,000 cu. ft. per day. Ultimately the Kansas Natural Gas Co. bought these and succeeded in extending its pipes to the wells during December. Many comparatively strong gas wells have been found scattered here and there over the whole field and westward throughout the Osage, but the amount of gas they would furnish in most cases would fall far short of justifying the outlay of capital in such a great extension of pipe-lines. During the summer, the Kansas Natural Gas Co. abandoned its booster station at Scipio, and moved the pumps to Oklahoma, where they will now be used in gathering the gas and forcing it to Grabham station, near Independence, Kansas. Early in the autumn the Kansas Natural Gas Co. went into the hands of receivers. It was generally understood that this was a friendly action in order to protect the company from numerous litigations and to enable it better to extend its pipe-lines over wide territory and deal with the problem of prices in towns and cities to which it delivers gas. The receivers at once began a careful investigation of the gas supply and then reported to the court early in December that they saw no grounds for hoping that the supply of gas available for Kansas City could be made greater than for the preceding year, and further that there was no doubt, in their opinion, that the entire supply would last at best but a few more winters.

PETROLEUM OUTPUT OF THE WORLD. (*a*)
(In metric tons.)

| | 1906 | 1907 | 1908 | 1909 | 1910 | 1911 | 1912 |
|---|---|---|---|---|---|---|---|
| United States | 17,862,000 | 22,287,985 | 24,401,728 | 24,433,528 | 28,331,000 | 29,001,100 | 29,906,416 |
| Russia | 8,167,934 | 8,435,708 | 7,654,600 | 8,037,300 | (*f*) 8,952,793 | 9,167,600 | 9,249,600 |
| Dutch East Indies | 1,186,907 | 2,200,000 | 2,348,000 | 1,497,275 | 1,700,000 | 1,670,688 | 1,520,000 |
| Galicia | 739,885 | 1,176,000 | 1,754,002 | 2,150,000 | 1,700,000 | 1,454 660 | 1,180,568 |
| Rumania | 887,000 | 1,129,097 | 1,147,727 | 1,263,946 | (*f*) 1,352,300 | 1,544 847 | 1, 806,942 |
| India | 564,470 | 587,000 | 568,000 | 905,336 | (*c*) 863,615 | (*c*) 907,684 | (*c*) 1,001,316 |
| Mexico | (*b*) | 294,000 | 587,000 | 405,000 | (*f*) 542,400 | (*d*) 968,277 | *d*) 2,646,000 |
| Other countries (*e*) | 367,000 | 296,000 | 293,000 | 505,000 | (*f*) 786,480 | 750,000 | 800,000 |
| Total | 29,775,196 | 36,405,790 | 38,754,057 | 39,197,385 | 44,236,973 | 44,465,856 | 48,110,742 |

(*a*) In the above table the statistics for the United States are computed from the production reported n barrels as given in the first table of this article. As a gallon of the crude petroleum found in the Jnited States varies in weight from 6.41 to 7.83 lb., the oil in a barrel varies from 269.22 to 328.86 lb. he arithmetical mean of these figures is 299.04 lb., which figure has been used as a factor in converting he output stated in barrels into metric tons. This is not strictly correct, because in the period from 900 to 1910 the proportion of petroleum production of various gravities has altered materially, espe- ally because of the largely increased production in California, Texas and Louisiana. However, the ethod adopted is as near an approximation as can be made at this time. (*b*) Included in other ountries. (*f*) *Oil Investors' Journal.* (*c*) On the assumption that 1 imp. gal. weighs 4.02 kg., uivalent to a density of 0.885. (*d*) On the assumption that 1 U. S. gal. weighs 3.5 kg., corre- onding to a density of 21°B., or 0.925. (*e*) Estimated.

## Petroleum in Foreign Countries

*Argentina.*—Considerable interest is being taken in the Commodoro Rivadavia oil fields and their development. Government officials consider it necessary to acquire one or two tank steamers for the transport of the oil and to construct tanks of 6000 cu. m. capacity in the ports of the capital, Bahia Blanca, La Plata, San Antonio, and Deseado, these last two for supplying the State lines in the territory. In Commodoro Rivadavia at present are four tanks of 6000 cu. m. capacity and eight of 200. It is further considered advisable to erect a refinery on the fields and also to continue sinking bore holes. All of this work is estimated to cost about $800,000, of which half will be spent in 1913. That the oil field is valuable is being confirmed daily by the results; well No. 4 early in 1913 came in as a gusher. At the present time a number of Diesel engine plants in Buenos Aires and other parts of the country are importing their supplies of oil.

*Australia.*—In New South Wales, the amount of oil shale produced in 1912 was 86,018 long tons (£34,770) compared with 75,104 tons (£36,980) in 1911. The mines of the British Australian Oil Co., at Murrurundi, in the northern district were actively worked throughout the year. In the western district, only three mines were operated, work having been suspended by the Commonwealth Oil Corporation. Payment of bounties by the Government during 1912 included £4017 on 482,050 gal. of kerosene, having a flash-point not below 73° F., and £848 on 338 long tons of refined paraffin wax.

The shale fields of Tasmania, in the Mersey district near the northern shore of the island, yield an oil that can be separated into products suitable for heating, illuminating, and lubricating. It is estimated that the seam extends over an area of 2000 acres and represents 12,000,000 metric tons of shale. It is reported that an oil concession has been applied for in the Northern Territory of Australia by Americans, who, it is believed, are associated with a Melbourne firm.

A large amount of capital has been expended in attempts to prove the value of oil deposits in various parts of the Taranaki district of New Zealand. At Moturoa, where the wells are close to the beach, the oil contains a large percentage of paraffin wax. Encouragement is given by the New Zealand Government to the incipient petroleum industry by means of a rebate of duty on oil-boring plant and machinery, while the Geological Survey is giving special attention to petroleum areas. Oil concessions have been granted over an area near Gisborne, Hawkes Bay district, on the east coast of North Island.

*Austria-Hungary.*—The output of oil in Galicia was 1,180,568 metric tons in 1912, compared with 1,455,660 tons in 1911, a decrease of 275,092

ons, or 18 per cent. This recession in output has been continuous since 1909, when the maximum of 2,076,740 tons was recorded. During 1912 he refineries treated 1,789,780 tons of crude oil, thus drawing on stocks ccumulated during previous years to the extent of 600,000 tons.

A merger of Galician oil companies was arranged in London in 1912. The Premier Oil & Pipe-Line Co. purchased the Amalgamated Oil Pipe-ines, of Galicia, the Central Carpathian Oil Co., the Alpha Petroleum Co. and some large tracts of land owned by individual operators. The apital stock of the consolidation was £3,750,000, divided into 1,200,000 reference and 2,500,000 ordinary shares. There seems to be a move-ient to merge the important Galician producers under Standard control.

*British North Borneo.*—Several years ago the Government granted a oncession to an exploration company for the sole right of exploring the erritory of the State—31,000 square miles. The efforts of the company o find oil were unsuccessful, but under the encouragement of the govern-ient and better conditions, research is to begin again. The concession omprising the entire petroleum rights of British North Borneo has been xtended until 1920. The Government has granted the syndicate a 99-year oil-mining lease over 440 square miles of territory on the Kilas eninsula, west coast of Borneo, the rental being 25 cents per annum and no oyalty on production. Drilling operations were carried on in this territory ntil July, 1911, when they had to be abandoned, owing to a breakage of asing at the bottom of the well, after a depth of 1058 ft. had been reached.

Meantime a concession had been obtained for the prospecting rights ver 220 square miles of territory in the state of Brunei, adjacent to Miri il field, Sarawak, belonging to the Shell Transport & Trading Co. Al-hough this territory is undoubtedly oil bearing, the broken nature of the ormation indicates that the oil-bearing anticlines will yield only a limited roduction of petroleum. It has been decided to proceed at once with he vigorous development of the Brunei territory and to provide the ecessary capital the whole of the assets of the old syndicate were sold to a new concern called the British Borneo Petroleum Syndicate, Ltd., having a capital of £120,000.

*Canada.*—The annual output of crude petroleum has steadily fallen off during the past 5 years. The output in 1912 was 243,336 bbl. ($345,050), as compared with 291,092 bbl. ($357,073) in 1911. The average price per barrel at Petrolea in 1912 was $1.42 or considerably higher than the average price in 1911, which was $1.23. The total bounty payments were $127,751 in 1912 and $152,823 in 1911. The production in Ontario in 1912 was 240,935 bbl. The production in New Brunswick in 1912 was 2679 bbl.

Imports of oil included crude oil, 120,082,405 gal. ($3,996,842);

refined illuminating oils, 14,748,218 gal. ($1.022,735); gasoline, 40,904,598 gal. ($5,347,767); lubricating oils, 6,763,800 gal. ($1,077,712); other petroleum products, 4,288,463 gal. valued at $413,477; wax and candles, 2,144,006 lb. ($119,520).

While the production of petroleum has been declining, the output and use of natural gas has been steadily increasing. The southern portion of Ontario has for many years been the principal source of gas, but the Albert County field in New Brunswick is now an important producer, while large developments are taking place in Alberta with such a rapid increase in output of gas that this province may soon take first place. The total production in Canada in 1912 was approximately 15,015,000,000 ft., valued at $2,311,126 and includes 12,534,000,000 in Ontario ($2,045,488) and 2,481,000,000 ft. in Alberta, ($265,638). The production in 1911 was 11,644,000,000 ft., valued at $1,907,678, including 10,864,000,000 ft. in Ontario ($1,807,513) and 780,000,000 ft. in Alberta ($110,165). These values represent the price received by the well owners or operators; the price paid by consumers is considerably greater.

Newfoundland is now regarded as a promising future source of petroleum. The director of the Geological Survey of Newfoundland has reported that indications of petroleum are met along the west coast from the vicinity of Port-au-Port Bay, for a distance of at least 200 miles northward. Operations in the immediate neighborhood of Parsons Pond have clearly demonstrated the existence of oil at that point.

*Dutch East Indies.*—The output of petroleum in 1912 was 1,520,000 metric tons, compared with 1,670,688 tons in 1911; it is believed that this diminution is only temporary. The East Indian oils are particularly valuable on account of their high volatility. They are refined mainly in western Europe; one factory in Amsterdam turns out 1000 tons of paraffine per year.

*Germany.*—According to the Imperial Ministry, 30 companies, employing 1900 people at wages of $525,000, are engaged in producing oil. The annual output averages 138,000 metric tons, derived from about 1100 wells. Total sales in 1911 were 140,697 tons for $2,305,906.

*Japan.*—The refinery output of the past 2 years was as follows, according to the London Board of Trade *Journal:*

| | 1911. | 1912. |
|---|---|---|
| | U. S. gallons | U. S. gallons |
| Naphtha | 208,916 | 333,818 |
| Kerosene | 21,523,434 | 21,674,660 |
| Neutral oil | 7,921,401 | 6,494,591 |
| Lubricating oils | 7,591,105 | 7,409,606 |
| Fuel oils | 30,051,498 | 26,771,382 |

U. S. gal. = 0.833 Imp. gal., or 6 U. S. gal. = 5 Imp. gal.

*India.*—The production of petroleum in 1912 is officially reported as 249,083,518 imp. gal., compared with 225,792,094 gal. in 1911 and 214,829,647 gal. in 1910. Except for 3,600,000 gal. from Digboi, in Assam, and 1500 gal. from the Punjab, the entire output is obtained in Burma.

Burma.—The production of petroleum in Burma for the last 3 years for which data are available was: 1909, 230,396,617 gal.; 1910, 211,507,903 gal.; 1911, 222,225,531 gal., valued at $4,201,585, $3,853,120, and $4,076,755, respectively. The chief oil deposits are in the vicinity of the Irawadi River and in Arakan, where a superior grade of paraffin-bearing oil is obtained at a moderate depth. The principal fields worked at present are the Yenangyoung in Magwe district, the Singu in Myingyan district, and the Yenangyat in Pakokku district. The latter is an expensive field to work, on account of topographic features; its oil, also, is deficient in paraffine. The production of crude oil at Digboi, in Assam, was 3,280,750 gal. in 1909 and 3,320,680 gal. in 1910. Small quantities of petroleum are obtained in the Rawalpindi district of the Punjab. The production in 1910 was 1064 gal. and in 1909 it was 720 gal. Many natural oil springs are known in Baluchistan, some of the most important occurring in the vicinity of Moghal Kot.

Exports of petroleum and its products from Rangoon during 1911 had an aggregate value of $17,864,920. Imports of American kerosene into Rangoon increased from $193,374 in 1909 to $202,328 in 1910, and $276,557 in 1911. Up to the present, the Burma oil companies have not been able to produce a non-smoking kerosene of high grade. European communities consume the American oil almost exclusively, while the natives use the cheaper local oil.

The refining of petroleum has become one of the most important industries of the country and is under the control of the Burma Oil Co., the Indo-Burma Petroleum Co., and the British Burma Petroleum Co. together operating seven refineries and employing 4047 persons. The Burma Oil Co. has a pipe-line from the oil fields for the transport of its crude oil. The other companies are dependent upon barges which come to Rangoon by the Irrawaddy River. The refineries are all located in or near Rangoon.

*Mexico.*—The petroleum industry of Mexico continues to increase; during 1912 additional wells were sunk and facilities provided for carriage of the oil and for treating it. The principal oil region yielded approximately 22,000,000 bbl., of which we estimate that 18,000,000 bbl. entered consumption during the year.

Shipments of crude petroleum from the Tampico district steadily increase. During 1912 declared exports to the United States amounted

to 7,142,658 bbl. In addition the Waters-Pierce refinery has been taking about 6,000 bbl. and the railway company about 12,000 bbl. daily. Consumption from these sources amounted to about 1,656,000 bbl. during the last quarter of 1912. In addition a considerable amount of crude oil was shipped to the Pearson refinery at Minitatlan, while a much greater amount was shipped there during the first quarter of 1913. A conservative estimate as to crude oil shipped from and consumed in the Tampico district during the December quarter would be about 5,000,000 bbl. This will probably be greatly exceeded during the first quarter of 1913. Because there are only 22 ft. of water at La Barra at Tampico, while at Tuxpam oil tankers can be loaded at sea, Tuxpam is rapidly displacing Tampico as the leading port for shipping crude oil.

A number of new companies are bringing in machinery and will shortly commence active exploration work in the oil fields. Some oil-well supply companies are now planning to open branch houses in Tampico, which will serve a useful purpose.

A great expansion of marketing facilities for the oil of the Tampico fields is taking place. Besides the pipe-lines under construction and being planned for the delivery of oil to Tampico, Tuxpam, and Vera Cruz, with one or possibly two lines running to Texas, much attention is being given to providing fleets of oil-carrying vessels. Pending the building of these vessels, tank farms are being constructed for the storage of the large quantities of oil that cannot be put on the market owing to the impossibility of chartering oil vessels.

The Mexican Petroleum Co., Ltd., and its subsidiary, the Huasteca Petroleum Co., received a net profit of $3,076,374 on operations in the Tampico territory during 1912. The annual report for that year states that the company has contracts calling for delivery of 14,000,000 bbl. of oil; at the beginning of 1912 it had contracts for about 10,000,000 bbl. or 28,000 bbl. per day. The average price in 1912 was 48 cents per barrel. Due to the unsettled conditions it is estimated that sales of oil for local use in Mexico were curtailed some 500,000 bbl. During 1912, shortage of steamers prevented about 250,000 bbl. from being delivered. The sales for the year 1912 were 8,662,700 bbl. Stocks on Dec. 31, 1912, amounted to 6,278,272 bbl. carried on the books at 27 cents per bbl., whereas its actual value early in 1913 was 65 cents. The No. 7 Casiano well, which flows about 23,000 bbl. per day, has not varied in its production since December 7, 1911. Its total yield thus far has been 21,000,000 bbl. The future of the Casiano wells is promising; only this one well has been permitted to flow, the others being capped.

The Compañia Mexicana de Petroleo El Aguila, S. A., has perfected

plans for a large crude-oil refinery in three or four units, to be constructed 3 miles from Tampico on the Mexican National branch runing to La Barra. The first unit, a topping plant, the only part to be constructed in 1913, will have a daily capacity of about 12,000 bbl. of crude oil. The refinery plans primarily to prepare a fuel oil meeting all Lloyd's requirements for marine use and also the requirements of the British Admiralty. This fuel oil will have a flash point over 150° F., and a viscosity under 1000. The equipment will be purchased partly in Europe and partly in the United States. Construction started in January and operations are to begin the latter part of 1913, with a much larger capacity than the Waters-Pierce refinery, in operation here for a number of years.

The budget law of Mexico for 1912–13 establishes a special internal tax on crude petroleum produced in the country, at the rate of 20 centavos (about 10 cents) per ton. The tax is regarded unfavorably by the numerous oil companies in Tampico, which claim that it will retard the development of the industry.

*Persia.*—The Anglo-Persian Oil Refinery, at Abadan, Persian Arabistan, started operations in December, 1912. Abadan is 44 miles below Bassorah, on the Persian side of the Shat-el-Arab. Oil was discovered several years ago above Awaz, about 140 miles inland from Abadan; wells were sunk, and a pipe-line laid to Abadan. The present daily capacity of the refinery is 24,000 gal.

*Peru.*—The output of petroleum in 1912 was 214,947 metric tons, compared with 200,000 tons ($2,919,900) in 1911, and 167,712 tons ($2,910,518) in 1910. The wells are all shallow and irregular in flow. At the end of 1911 crude oil was selling for $10.95 at $12.15 per metric ton at Callao, kerosene for 34 cents per gallon and benzine for 27 cents per gallon, according to the U. S. consul at Callao.

A new petroleum company has been formed in Panama, with a capital of $400,000 gold, to exploit Peruvian oil fields, with a refinery at Panama. The company proposes to acquire oil lands in the Talara region, ship the crude oil to Panama, refine it there, and sell in the Caribbean and Central American markets.

*Roumania.*—The output of petroleum during the calendar year 1912 was 1,806,942 metric tons, compared with 1,544,847 tons in 1911, according to the German Petroleum Joint Stock Co. The official statistics for fiscal years are as follows:

PETROLEUM PRODUCTION OF ROUMANIA.
(In metric tons.)

| | Prahova. | Dambobita. | Bussau. | Bacau. | Total. |
|---|---|---|---|---|---|
| 1902–03 | 288,077 | 23,411 | 4,849 | 8,399 | 324,736 |
| 1903–04 | 370,198 | 27,714 | 5,629 | 8,849 | 412,390 |
| 1904–05 | 480,848 | 28,725 | 10,184 | 10,770 | 530,527 |
| 1905–06 | 631,924 | 25,528 | 13,496 | 10,547 | 681,496 |
| 1906–07 | 928,173 | 24,579 | 11,827 | 9,430 | 974,010 |
| 1907–08 | 988,987 | 31,721 | 10,203 | 10,822 | 1,041,733 |
| 1908–09 | 1,082,100 | 25,966 | 14,491 | 16,486 | 1,139,043 |
| 1909–10 | 1,280,288 | 19,455 | 26,583 | 18,580 | 1,344,906 |
| 1910–11 | 1,211,319 | 49,433 | 42,521 | 22,470 | 1,235,743 |
| 1911–12 | ..... | ..... | ..... | ..... | ..... |

The amount of crude oil delivered to refineries in 1911 was 1,404,400 metric tons, an increase of 15 per cent. over the 1,125,300 tons delivered in 1910. The yield from the refineries in 1911 was: Benzine, 260,653 metric tons; burning oil, 312,711 metric tons; "mineral oil," 24,703 metric tons; and residue, 783,136 metric tons. The great majority of the benzine and kerosene is exported; of the "mineral oil" only about one-third is exported, while much the greater part of the residues are consumed for fuel in Roumania.

*Russia.*—According to the *Neftiannoie Dielo*, the total output of petroleum in Russia in 1912 was 564,000,000 poods, of which the Baku district and its adjacent fields were responsible for 473,000,000 poods. The table below has been computed on the basis that 1 pood is 36.11 lb., or 16.4 kg.; whence 1,000,000 poods = 16,400 metric tons:

PRODUCTION OF PETROLEUM IN RUSSIA.
(In metric tons).

| Districts. | 1910. | 1911. | 1912. |
|---|---|---|---|
| Baku: | | | |
| Four main areas | 7,839,200 | 6,970,000 | 6,871,600 |
| Hand dug wells | 49,200 | 98,400 | 164,000 |
| Surakhani | 164,000 | 328,000 | 508,400 |
| Binagadi | 147,600 | 114,800 | 164,000 |
| Sviatoi Island | 16,400 | 49,200 | 49,200 |
| Grosny | 1,213,600 | 1,230,000 | 1,066,000 |
| Tcheleken | 164,000 | 196,800 | 196,800 |
| Maikop | 16,400 | 131,200 | 147,600 |
| Ferghana | 32,800 | 49,200 | 65,600 |
| Emba | ..... | ..... | 16,400 |
| Total Russia | 9,643,200 | 9,167,600 | 9,249,600 |

Boring in the Baku fields during 1912 continued at an increasing rate. During the first 11 months new boring amounted to 347,816 ft., as against 287,035 ft. bored during the corresponding period of 1911, an increase of 17.7 per cent. During the last quarter of the year a slight decline in boring activity was noticeable, which may be partly explained by the expectation of the opening of the exploitation of the State reserve

areas. The enormous increase in the Surakhani production corresponds with an increase in boring—49,175 new ft. for 10 months of 1912, as against 14,959 ft. bored during 10 months of 1911. The Grosny production during 1912 was 164,000 tons less than that of 1911, this notwithstanding the considerable increase in boring. New boring during the 11 months of 1912 amounted to 109,893 ft., as against 68,110 ft. bored during the corresponding months of 1911, showing an increase of 41,683 ft., or 61.4 per cent.

(By E. de Hautpick)[1] Baku.—The production at Baku in 1912 amounted to 7,039,133 British tons, against 7,870,000 tons in 1911; 8,120,000 tons in 1910; 9,680,000 tons in 1909; 10,000,000 tons in 1904; 10,025,300 tons in 1902; and 10,758,000 tons in 1901 (record year for production and low price—10s. 4d. per ton crude oil). Thus the fall in the production at Baku has gone on systematically for 11 years and has almost reached 50 per cent. The wells now have to be drilled twice as deep as before, and the number of exploited wells is now four times as many, obviously involving an increased cost of production, and a higher first cost. Of the various oilfields in the Baku region in the course of the past 10 years, the largest producer has been Sabunchy, then Bibi-Eybat, Ramany, and Balachany. The last is the most exploited. The greatest variations in production are observed in the Sabunchy field. In the general increase in the number of wells, the most rapid progress is seen at Sabunchy and Bibi-Eybat. The average depth of well is much the largest at Bibi-Eybat and Ramany, and the most productive wells have been in these two fields. The Balakhany wells yield the smallest production. With the object of increasing the area of the land for exploiting petroleum at Bibi-Eybat, a belt of the Caspian Sea embracing 800 acres was filled in and joined to the mainland. Besides the four principal oil fields at Baku, petroleum is produced at Surakhany—black and white oil as well as natural gas. In the production at Surakhany, a considerable quantity of petroleum is delivered by spouters. The Binagadi oil field is exploited, not by boreholes, of which there are only sixteen, but by excavations, of which there are about 3000. These yield 160,000 tons crude oil. We must add also to the Baku production the exploitation of the Nobel Brothers' wells on the island of Sviatoi in the Caspian Sea. The total area of all the oil fields now under exploitation at Baku comes to 2700 acres.

Grosny.—The production of the Grosny oil field in 1912 amounted to 1,054,440 British tons, against 1,212,090 tons in 1911, 1,191,419 tons in 1910, 920,000 tons in 1909, 839,669 tons in 1908, 635,640 tons in 1907, 528,588 tons in 1903, 495,000 tons in 1900, and 129,030 tons in 1893.

[1] *Min. Journ.*, Jan. 11, 1913.

The last-named year must be considered as the year when the Grosny oil industry was established. The average depth of all the exploited wells at Grosny in January, 1901, was 878 ft. In January, 1912, it was 1675 ft. The average daily production of each well, which gradually rose of recent years and reached 20 tons per day in December, 1910, began to fall in 1911, and in 1912 it amounted to 12 1/3 tons only. This average daily production at Grosny, however, is twice as much as at Baku or Maikop. All the production of petroleum at Grosny is distributed among fourteen firms, and almost three-quarters of it falls to the three largest concerns—the Spies Company (English), the Akhverdoff (Belgian), and the Kazbek (controlled by the Rothschilds of Paris).

All the trade in the Grosny petroleum is in the hands of Nobel Brothers; at present only the railway route is available. A project is under examination for the construction of a Grosny pipe-line to Tuapse, via Maikop. There is also a project of connecting Grosny to the Caspian Sea by a pipe-line, 85 miles long. The greatest difficulty for Grosny development lies in the conditions under which petroleum allotments are leased —namely, for 24 years, at the termination of which the rights to the oil lands cease, and these return into the control of the Government. During this period it is impossible to get back the great outlay involved in properly exploitating these allotments, since the wells are being bored very deep, 2800 to 3800 ft., which calls for great expenditure and several years in time.

The area now occupied by exploitation does not include the whole Grosny petroliferous area. A considerable area (about 2000 acres) still remains undrilled.

Maikop.—The production of petroleum in the Maikop oil field in 1912 amounted to 138,679 British tons, against 125,000 tons in 1911, 22,600 tons in 1910, and 3320 tons in 1909. The number of active wells in Jan., 1912, was 17, and in Jan., 1913, was 79. The boring done in the Maikop oil field in 1911 showed, as in the preceding year, the absence of petroleum in paying quantities in the western part of the district, from Nephtianoy to Hadizhensky and Kabardinsky, and also in the east from the first Shirvansky gusher to the village of Samoorsky. Although the production of petroleum on the Maikop oil field for 1912 exceeded that of 1911 by a little, the number of active wells increased nearly four fold.

Tcheleken.—In 1907, vigorous spouting wells were first observed on this island in the Caspian Sea, but after continuing, even into 1911, they began to weaken, and water began to appear in them. The petroleum is now produced by pumping. There are now 60 active wells, whence the average daily production per well is about 10 tons. In 1912 about

20 concerns were at work. Tcheleken oil is produced from Miocene strata. Only one productive petroliferous level has been found, which has been the source of all the Tcheleken gushers.

Ferghana.—The production of petroleum in the Ferghana oil field in 1912 amounted to 58,400 British tons, against 40,200 tons in 1911, 28,200 tons in 1910, 14,100 tons in 1909. The Ferghana oil fields have attracted attention since 1904, when the Chimion company struck a flowing well at a depth of 1050 ft. But the productivity of this oil field began to decline in 1907, and is now unable even to satisfy the needs of the railway, which obtains liquid fuel for its locomotives from Baku viâ Astrachan and Samara. The Ferghana oil fields are situated in Turkestan, Central Asia, on the slopes of the Altai hills, and consist of separate fields—Sel Rokho, Uaili Sai, Chur Soo, Chimion, Kechel Mai, and Reshtan.

Ural-Caspian.—North of the Caspian Sea, from the point where the Ural River falls into it, eastward across the River Emba to the Mugodzhar mountains, there is an immense petroliferous area, which, in the course of 1912, has been made ready to become a furnisher of petroleum to Eastern Russia. There are some productive wells at Doss-Sor, whence there is a pipe-line to the Caspian Sea. Boring and prospective work have deen done in many parts (Machat, Kara Chungul, Kara Tan, Iskene, Bek Beke, Cheerkala). The quality of the Ural-Caspian oil is excellent. It is a light oil with paraffin base, and at 60° F. has a specific gravity of 0.861 to 0.870, yielding 20 per cent. benzine, 42 per cent. kerosene, and 38 per cent. liquid fuel. Work was done on these oil fields during 1912 by Nobel Brothers (Emba Company), and the Ural-Caspian Oil Corporation.

*Trinidad.*—The oil fields of Trinidad are mainly in the southern part of the island and are being energetically worked. The number of additional wells drilled during the year 1911–12 was 46, making the total number 90. During the year 8,786,871 imp. gal. of oil, valued at $279,700, were exported from Trinidad.

One of the finest oil wells in the colony was struck in September, 1912, at Perseverance Estate, Guapo. At a depth of 296 ft. the oil spouted through a 6-in. pipe about 60 ft. in the air. Much of the oil was lost by the failure of the earth reservoirs. Negotiations between local financiers and the Consolidated South African Co. were broken off by the latter. Great benefit was expected to come from the interest of so wealthy a concern in the Trinidad oil fields. A new company, known as the Silver Stream Oil Fields Co., has been transporting machinery to the banks of Godineau River, district of Oropouche, to bore for oil.

The General Asphalt Co., during 1912, proved the productivity of

the Morne l'Enfer oil sands. Five wells were completed at points two miles from the oil fields adjoining Pitch Lake. The production from this source in 1912 was 247,208 bbl., and for 1911 (ending Jan. 31, 1912) it was 141,233 bbl. The rate of production early in 1913 was increasing.

*Venezuela.*—The Bermudez Company has selected 28 areas of 500 hectares each for operating. Eighteen are near Bermudez asphalt lake, four on Pederuales Islands, three at Mari-Mari, and three at Yaguaropara. The one well in the first locality is 562 ft. deep, but is not completed. Heavy liquid asphalt flows steadily from the 12.5-in. casing, but this will be sealed off and the well continued. The Caribbean Petroleum Company is proceeding with the systematic examination of its consession.

*West Africa.*—The occasional occurrence of bituminous sands in the Gold Coast and in Nigeria has led to exploration for petroleum, and oil has been found. Several samples of crude petroleum obtained at Bonyere, in the Axim district of the Gold Coast Colony, have been examined at the Imperial Institute, and were found very deficient in light volatile compounds. The Société Française de Pétrole (Ltd.) controls an area of 150 square miles in the Gold Coast Colony and 19 square miles in the (French) Ivory Coast Colony; drilling is in progress. In Southern Nigeria, the southern Nigeria Bitumen Corporation is actively employed in boring operations.

## Progress in the Technology of Petroleum Refining

Thomas T. Gray

The most important development in petroleum refining during 1912 was the manufacture of gasoline from fuel and gas oils, by distillation under pressure. This process was patented Jan. 7, 1913, by William M. Burton, manager of the Standard Oil Co. plant at Whiting, Ind., where it is being used on a large scale for the manufacture of "Motor Spirits," the name under which the gasoline made by this process is being put on the market.

*Pressure Distillation.*—A process heretofore not looked upon with favor on account of the danger involved enables the refiner to convert heavy, high boiling-point oils, like fuel or gas oils, into light, low boiling-point products like gasoline and burning oil. The decomposition which takes place with the formation of the lighter products causes also the production of heavy oils and free carbon, depending upon the extent to which the operation is carried. As the free carbon produced collects on the bottom of the still forming red spots, it is not practical in the present state of the art to carry the destructive distillation under pressure to dryness.

As found in the market, "Motor Spirits" averages about 60° Béaume gravity, has a pronounced odor, and pale straw color, and, it is claimed, is composed principally of hydrocarbons of the paraffin series. The almost universal prejudice against the Standard Oil Company, has no doubt been the cause of a good deal of unjust criticism of "Motor Spirits;" it is said, however, to be equal to gasoline for motor use, and is about 3 cents cheaper per gallon. As it is thought that Burton's patent will stimulate the practical application of other processes involving pressure distillation, an abstract of it is given:

The patent (U. S. Patent 1049667, Jan. 7, 1913) was assigned by William M. Burton to the Standard Oil Co., of Whiting, Indiana. The invention relates to the treatment of high boiling-point residuals, and particularly the residue of the distillation of the paraffin group or series of petroleum, after the lower boiling distillates are removed, in order to obtain a low boiling-point product of the same series. The methods of distilling from crude petroleum have been improved in recent years, in order to obtain naphtha on account of the growing demand for gasolene. The boiling-points of these naphthas range from about 75 to 350° F. This leaves illuminating oils (boiling-points from 350 to 600° F.), and the lubricating oils and waxes, and as residue, fuel oil and gas oil, with boiling-points ranging from about 600 to 700° F. The attempt to obtain gasoline from this residue by lowering the boiling-point, have invariably changed the formula of the paraffin group ($C_nH_{2n}+2$), to that of the ethylene group ($C_nH_{2n}$, rendering the product unmarketable on account of its offensive odor. Fuel and gas oil have been treated by destructive distillation, for obtaining a low boiling-point product. The resulting vapors are conducted through a condenser by way of a pipe connecting it with a still, with a loaded valve interposed in the pipe to maintain pressure in the still. The condensed product, however, is found to have been converted into the objectionable ethylene group.

The object of Mr. Burton's invention is to treat the residue of the paraffin group in such a manner that the resultant low boiling-point product shall be of the same paraffin series, avoiding the ethylene series. This is accomplished by raising the boiling-point of the liquid residue by means of back pressure on the liquid and vapors, which are maintained under pressure throughout their course from the still through the condenser, and while undergoing the condensation.

The apparatus consists of a boiler equipped with a safety valve, fire-place, pressure gage and thermometer. A pipe leads from the top of this boiler to a condenser, consisting of a coil immersed in the usual cooling tank. From near the lower end of this coil, a small pipe leads up to a relief valve, and lower down, connecting to a receiver for the

products of condensation, is a shut-off valve. This valve is normally closed. The relief valve allows any excess gas pressure to escape. The pressure with the shut-off valve closed, is from 4 to 5 atmospheres, raising the boiling-point from 500 to 750 or 800° F. This pressure combined with the temperature, greatly increases the conversion of the high-boiling members of the paraffin series, into the low-boiling members of the same series. The inventor does not account for the reasons why this back pressure effects this result. The claims stated in the invention are as follows:

1. The method of treating the liquid portions of the paraffin series of petroleum distillation having a boiling-point upward of 500° F. to obtain therefrom low boiling-point products of the same series, which consists in distilling at a temperature of from about 650 to about 850° F. the volatile constituents of said liquid, conducting off and condensing said constituents, and maintaining a pressure of from about 4 to about 5 atmospheres on said liquid of said vapors throughout their course to and while undergoing condensation.

2. The method of treating the liquid portions of the paraffin series of petroleum distillation having a boiling-point of upward of 500° F. to obtain therefrom low boiling-point products of the same series, which consists in distilling off at a temperature of from about 650 to about 850° F. the volatile constituents of said liquid, conducting off and condensing said constituents, maintaining a pressure of from about 4 to 5 atmospheres on said liquid of said vapors throughout their course to and while undergoing condensation, and releasing from time to time accumulations of gas from the products of condensation.

The presence of unsaturated hydrocarbons in the Burton product gives it an odor which would preclude its use for many purposes. This fact draws attention to Dr. David T. Day's process for the refining and purifying of hydrocarbon oils, patented July 17, 1906, and apparatus for treating hydrocarbon oils, patented October 3, 1911. Day's patent, in addition to distillation under pressure, includes hydrogenation and therefore the production of sweet-smelling products.

The process of decomposition by distillation under pressure always causes the formation of unsaturated hydrocarbons, and therefore ill-smelling products. By Day's method the hydrocarbon vapors are mixed with hydrogen gas and brought into contact with a suitable catalytic agent. For the purpose of promoting the chemical combination of the hydrogen and unsaturated hydrocarbons, thereby changing them to the paraffin (saturated) series. Day's method seems to have the advantage of producing a gasoline of sweet odor and of the same character and quality as that obtained naturally by the distillation of crude petroleum.

As it is thought that these patents will have much to do with the further development of the petroleum industry, the claims are given in abstracts:

The patent of David T. Day, patent 1004632, Oct. 3, 1911, is an improvement on previous patents secured for the same purpose (U. S. patent No. 826089, July 17, 1905). He claims as his invention the following:

1. The combination with an oil still, of a hydrogenator therein, comprising two vapor chambers, an intermediate oil chamber, tubes connecting the vapor chambers, the partition between the oil chamber and one vapor chamber having an opening for the passage of vapors to the tubes, and a goose neck or vapor escape pipe connecting with the other vapor chamber.

2. The combination in addition with a pipe leading from a source of supply of hydrogen-carrying gas or vapor, connecting with the oil chamber.
3. The combination with the hydrogen supply pipe, and an additional vapor escape pipe with the second vapor chamber.
4. The combination of the above with a generator for supplying hot gas or vapor.
5. The combination of the above, of a valve for controlling the pressure and temperature of hydrogen and distilled oil vapor, in contact with a contact material.

The claims of the earlier patent are substantially as follows: The process of treating hydrocarbon oils by subjecting them to the action of added or absorbable hydrogen or hydrocarbons, in the presence of porous absorptive substances; also the same underpressure; also the process of purifying and deodorizing hydrocarbon oils by passing them through absorptive porous substances charged with hydrogen, etc., also the purifying and deodorizing of hydrocarbon oils by the action of palladium black or platinum sponge.

*General Processes.*—The general processes of refining petroleum have changed but little since 1911; some few refinements of minor note have been accomplished, but there have been no changes in processes of sufficient importance to include in the present article.

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——————— "Die Petroleumfunde in Argentinien und ihre Bedeutung." (*Montan Ztg.*, Nov. 15, 1912.)

——————— "Die Verkehrs- und Handelsvorschriften für das Petroleum in den einzelnen Landern." (*Petroleum*, Oct. 14, 1912.)

——————— "Das Reichspetroleummonopol." (*Min and Eng. Wld.*, Nov. 6, 1912, p. 125.)

——————— "Fallacies in the Theory of the Organic Origin of Petroleums." (Inst. of Min. and Met., *Bull.* 87, Dec. 14, 1911.)

# PHOSPHATE ROCK

The output of phosphate rock exceeds 6,000,000 tons annually; of this the United States consumes about 2,000,000 tons and produces about 3,000,000 tons. In 1912[1] the marketed output in the United States was 2,973,332 long tons, valued $11,675,774 as against 3,123,584 tons valued $12,237,111 in 1911. The latter was the largest record. The year 1911–1912 was an off year as far as the fertilizer industry is concerned. The industry up to the two preceding years had made steady advances. The stocks of raw material accumulated in the south proved to be much larger than anticipated. The output of the manufactured article in 1912 decreased probably 15 per cent. A consequent cutting of prices had been a decided feature in 1911–1912; the present conservative methods of the manufacturers are the result of these conditions. The heavy stocks of raw material are gone and sales in the early part of 1913 were large, owing to favorable weather conditions unlike 1911–1912, for early planting.

Prices of rock which had fallen from an average of $4.11 in 1910 to $3.90 in 1911, were again advanced.

PRODUCTION OF PHOSPHATE ROCK IN THE UNITED STATES. (a)
(In tons of 2240 lb.)

| | 1909 | | 1910 | | 1911 | | 1912 | |
|---|---|---|---|---|---|---|---|---|
| Phosphate. | Tons. | Value. | Tons. | Value. | Tons. | Value. | Tons. | Value. |
| Florida hard rock... | 527,582 | $4,136,243 | 392,088 | $2,940,660 | 474,094 | $2,953,606 | 536,379 | $3,218,274 |
| Florida land pebble. | 1,334,569 | 4,751,066 | 1,637,709 | 6,550,836 | 2,020,477 | 6,809,007 | 2,043,486 | 7,101,186 |
| Florida river pebble. | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Total, Florida..... | 1,862,151 | $8,887,209 | 2,029,797 | $9,491,496 | 2,494,571 | $9,762,613 | 2,579,865 | $10,319,460 |
| Car. land rock.... | 197,000 | $648,838 | 185,000 | $786,250 | (b)169,156 | $673,156 | (b)131,490 | $ 524,760 |
| Car. river rock... | 9,500 | 33,250 | 16,347 | 57,314 | *nil* | ..... | ..... | ..... |
| Total S. Carolina. | 206,500 | $701,088 | 201,347 | $843,564 | 169,156 | $673,156 | 131,490 | $ 524,760 |
| Tennessee..... | 388,380 | $1,456,425 | 440,699 | $1,586,516 | 542,761 | $1,918,489 | 443,065 | $1,710,000 |
| Other States..... | 6,735 | 23,500 | 10,095 | 40,380 | (c) 10,505 | 39,882 | (b)11,612 | 46,450 |
| Total, U. S..... | 2,463,766 | $11,068,222 | 2,681,938 | $11,961,956 | 3,216,993 | $12,394,140 | 3,166,032 | $12,600,670 |

(a) Statistics collected by MINERAL INDUSTRY, except as otherwise noted. (b) Reported by the U. S. Geol. Survey. (c) Idaho, Utah and Wyoming.

[1] *U. S. Geol. Surv.*

STATISTICS OF PHOSPHATES IN THE UNITED STATES. (a)
(In tons of 2240 lb.)

| Year. | Production. | Imports. | Exports. (b) | Consumption. | Year. | Production. | Imports. | Exports. (b) | Consumption. |
|---|---|---|---|---|---|---|---|---|---|
| 1901... | 1,483,723 | 180,714 | 729,539 | 934,898 | 1907.. | 2,251,459 | 25,896 | 1,018,212 | 1,259,143 |
| 1902... | 1,600,813 | 145,793 | 802,086 | 944,250 | 1908.. | 2,375,031 | 26,734 | 1,196,175 | 1,205,590 |
| 1903... | 1,581,576 | 153,972 | 785,259 | 950,289 | 1909.. | 2,463,766 | 11,903 | 1,020,556 | 1,455,113 |
| 1904... | 1,874,428 | 166,090 | 842,484 | 1,198,034 | 1910.. | 2,681,938 | 19,319 | 1,083,037 | 1,618,220 |
| 1905... | 1,933,286 | 82,072 | 934,940 | 1,080,418 | 1911.. | 3,216,993 | 16,153 | 1,246,577 | 1,980,569 |
| 1906... | 2,052,742 | 46,228 | 904,214 | 1,194,756 | 1912.. | 3,166,032 | 28,821 | 1,206,520 | 1,988,333 |

(a) Production statistics of 1901 and subsequent years, except 1905–1911, are those of the U. S. Geological Survey and are based on marketed products. (b) Neglecting the insignificant exports of foreign product.

The crude phosphate exports were valued at $7.45 per ton.

The imports of fertilizers of all kinds into the United States were as follows:

IMPORTS OF FERTILIZERS INTO THE UNITED STATES.
(In tons of 2240 lb.)

| | 1909. | | 1910. | | 1911. | | 1912. | |
|---|---|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| Guano..... | 37,766 | $734,636 | 44,268 | $699,949 | 35,869 | $774,313 | 19,128 | $329,624 |
| Crude phosphates. | 11,903 | 97,277 | 19,319 | 235,040 | 16,153 | 157,394 | 28,821 | 231,255 |
| All other fertilizers (a). | ..... | 5,770,454 | ..... | 6,870,164 | ..... | 5,169,694 | ..... | 5,452,330 |

(a) Except potash and ammonia salts.

Manure salts (included in others), in 1912 were 171,756 tons valued $1,797,057; other manures 127,932 tons, $2,660,887; basic slag ground and unground 12,596 tons valued $114,300; bone-dust 117,716 tons valued $878,686; apatite 100 tons valued $1400; not included in others were Kainit 511,976 tons valued $2,386,362; cyanamide or lime nitrogen. 7407 tons valued $390,039.

Of the exports, including other fertilizers valued $2,000,000 in 1912, these were distributed among these countries:

| | Tons. | Dollars. |
|---|---|---|
| Phosphate rock, not acidulated: | | |
| High-grade hard rock[1]..... | 249,480 | 2,494,800 |
| Land pebble[1]..... | 370,759 | 2,181,070 |
| All other[1]..... | 586,281 | 4,320,586 |
| All other fertilizers..... | 74,587 | 2,039,995 |
| Exported to— | | |
| Belgium..... | 127,684 | 864,549 |
| France..... | 120,011 | 728,462 |
| Germany..... | 340,921 | 2,995,572 |
| Italy..... | 95,267 | 622,980 |
| Netherlands..... | 161,680 | 1,261,360 |
| United Kingdom..... | 166,911 | 1,188,692 |
| Other Europe..... | 139,835 | 1,045,652 |
| Canada..... | 37,860 | 678,784 |
| West Indies and Bermuda..... | 34,227 | 1,123,547 |
| Japan..... | 52,331 | 354,942 |
| Other countries..... | 4,380 | 171,911 |

[1] Not separately stated prior to July 1, 1912.

A good deal of the rock exported (hard rock), is manufactured into superphosphate in foreign countries. Belgium for example is importing an increasing amount of rock for this purpose and also furnishes the United States with superphosphates to about the same value as these exports each year.

In the United States the south is the great consumer of fertilizers. Possibility of developments of Western phosphate deposits depend largely on transportation and proximity to both a source of sulphuric acid and the agricultural centers. The agriculture is established; the phosphate industry together with acid will be developed as the market demands, although an outlet for possible acid in the west is much to be desired.

Of the total United States production of phosphate mined, only a small per cent. is used as ground rock. This is estimated from Tennessee as about 30,000 tons. The balance is all treated with sulphuric acid.

Attention to the Newberry Fishburne process is attracted by the reported erection of the first plant in Tennessee. The use of sulphuric acid may be much decreased in time. The use of the acid for another fertilizer, namely, ammonium sulphate, will probably keep pace with this reduction.

*Florida During* 1912 (By E. H. Sellards, State Geologist).—The production of phosphate rock in Florida which has steadily increased during the past several years shows according to statistics collected by the State Geological Survey a further increase during 1912. The output for 1911 was 2,494,572 long tons, while during 1912 the output as reported to the State Geological Survey by the producers was 2,579,865 long tons, an increase of nearly 100,000 tons. The increase occurred in both the hard rock and pebble mines. It was greatest, however, in the hard rock mines, this being the reverse of the preceding few years during which the increase had been most rapid in the pebble mines. Thirty companies in all were engaged in mining phosphate in Florida during 1912. Of these fourteen companies were mining hard rock phosphate while sixteen companies were mining pebble phosphate.

The foreign shipments of phosphate rock from Florida during 1912 amounted to 1,203,005 tons. The amount consigned for domestic shipment as reported by the producers, was 1,219,927 tons. It thus appears that approximately one-half of the phosphate mined in Florida is used in the United States. Hard rock phosphate is said to have sold at the mines during 1912 at about $6.00 per ton. Pebble phosphate sold at the mines at $2.75 to $4.50 per ton depending upon the grade.

Hard Rock Phosphate.—Notwithstanding a season of unprecedented rain the mining of hard rock phosphate progressed actively during

1912 resulting in a decided increase in production over the preceding year. The production of hard rock during 1911 in Florida was 474,094 tons while during 1912 there was mined 536,379 tons. The removal of overburden by hydraulics is becoming very general in the hard rock section and has been an important factor in the increased production of rock. Electric lighting and power has made it possible to introduce day and night shifts in the Withlacoochee River mines, one or two plants near Dunnellon having been so operated during 1912. The total number of plants mining hard rock phosphate at the beginning of 1912 was forty-three. Some of these worked out deposits or for other reasons closed down, while several new plants opened up. Forty plants were operating in the hard rock section at the close of the year.

The domestic shipments of hard rock phosphate during 1912 amounted to 15,425 tons, of which 10,449 tons were consigned for use in Florida. The amount of hard rock consigned for export, as reported by the producers, was 473,639 tons, as against 462,072 tons during 1911. The amount of hard rock phosphate actually loaded for shipment during 1912 at the various ports was 470,354 tons.

Pebble Phosphate.—The production of pebble phosphate during 1912 shows a slight increase over that of 1911. The output of pebble for 1911 was 2,020,478 tons while during 1912 the output was 2,043,486 tons. The number of plants engaged in mining pebble phosphate in Florida during 1912 was sixteen, although several mines are frequently worked from one plant. The overburden from the pebble rock is removed by steam shovel or by hydraulics. The rock itself is mined by hydraulics or by steam shovel. Many of the pebble mines run day and night shifts.

The amount of pebble phosphate consigned during 1912 for domestic use, as reported by the producers, was 1,204,502 tons, of which 32,425 tons were consigned for use in Florida. The amount of pebble rock consigned for export during 1912 as reported by the producers, was 682,232 tons. The amount of phosphate actually loaded and cleared for shipments through the several ports during the calendar year 1912, as reported in the American Fertilizer, January 25, 1913, was 732,651 tons, from which it appears probable that a small amount of phosphate sold by the producers to parties in the United States and hence reported by them as domestic shipments, was subsequently exported. The amount of phosphate actually loaded at the ports is used in giving the total exports. The statistics on the production of phosphate rock have been obtained directly from the producers and are complete for all plants operated in Florida.

STATISTICS OF FLORIDA PHOSPHATE.
(In long tons.)

| Year. | Production. | | | Total Shipments. | Domestic Consignments. | Exports. |
|---|---|---|---|---|---|---|
| | Hard Rock. | Pebble. | Total. | | | |
| 1909 | 527,582 | 1,334,569 | 1,862,151 | 1,843,203 | 837,217 | 1,005,986 |
| 1910 | 392,088 | 1,637,709 | 2,029,797 | 2,081,936 | 1,014,473 | 1,067,463 |
| 1911 | 474,094 | 2,020,477 | 2,494,571 | 2,456,440 | 1,290,779 | 1,165,661 |
| 1912 | 536,379 | 2,043,486 | 2,579,865 | 2,422,932 | 1,219,927 | 1,203,005 |

*Tennessee.*—The production fell off as shown in the table; 19 operators continued to produce, mostly in Maury County, as compared with 47 producers in 1911. In that year the exports were about 4000 tons of the better grade material up to $4.50 per ton.

The phosphate brown rock, appears usually concentrated in layers, and contains 50 per cent. of phosphate. The darker streaks containing organic matter weather to brown. The lump from such rock may be as high as 73 per cent. phosphate. The mining of the rock and removal of the overburden is now done by machinery such as steamshovel or giant in a number of cases. The treatment or preparation, and the separation of the troublesome clay is being attempted on a larger scale than before; waste dumps are being treated and the product is more valuable and uniform than in the days of shipments from the mine only. A description of improvements in this direction is given by L. A. Barr.[1]

*South Carolina.*—The land rock continues to be produced, mining with mechanical appliances such as clamshells and shovels. The treatment in washers and duers is similar to the hard rock treatment in Florida. The production was less than in 1911.

*Other States.*—Only one underground mine was working in Arkansas recently near Batesville. The Idaho steep phosphate beds near Montpelier were worked on a preliminary scale, the rock being shipped directly to the coast. Deposi' in Utah and Wyoming gave some production. The Idaho and Montana phosphates are described by A. R. Schultz, R. W. Richards and J. T. Pardee.[2]

The phosphate field of Idaho, Montana, Utah and Wyoming, most of which belongs to the government, is the largest ever discovered in the world, according to the U. S. Geological Survey. The exact boundary of the phosphate-bearing area is gradually being determined by detailed and reconnaissance examinations, and the original tract of 4,541,300 acres, withdrawn Dec. 9, 1908, as a phosphate reserve, has been altered from time to time by the restoration of non-phosphate areas and by

[1] Proc. Engg. Association of the South, 1912; Lucius P. Brown, American Fertilizer Hand-book, "Tennessee Phosphate Mining."
[2] *Bull.* 530 H. *U. S. Geol. Surv.*, 1912.

additional withdrawals. On Sept. 1, 1912, the outstanding land withdrawn in this general region amounted to 2,211,867 acres.[1]

The phosphate industry of southeastern Idaho continues to drag by reason of adverse freight rates and Federal withdrawals. The U.S. Geological Survey continued its study of this field in 1912 and has now outlined a resource of several billion tons of 70 per cent. phosphate rock occurring in well-defined beds. If these deposits were opened to the public and a free hand given for their exploitation and development, as such a vast volume of mineral warrants, an important industry would doubtless be developed.[1]

## Notes on the Foreign Phosphate and Fertilizer Industry

Most of the world's trade in phosphate rock is from localities with cheap transportation on the sea board. For superphosphate manufacture, cheap acid is produced at the point of delivery and the fertilizer market is nearby, as it usually is with the crowded conditions of farming in Europe. The production in foreign countries is as follows:

PRODUCTION OF PHOSPHATE IN THE WORLD.
(In metric tons.)

| | 1905. | 1906. | 1907. | 1908. | 1909. | 1910 | 1911. | 1912. |
|---|---|---|---|---|---|---|---|---|
| Algeria | 334,784 | 333,531 | 315,000 | 452,060 | 351,491 | 319,069 | (d) 332,897 | 388,515 |
| Angaur (Palan Inseln.) | ..... | ..... | ..... | ..... | 9,000 | 45,000 | 41,000 | 50,000 |
| Belgium | (b) 193,305 | (b) 152,140 | 181,230 | 198,030 | 205,260 | 202,880 | 196,780 | ..... |
| Canada | 1,180 | 930 | 680 | 1,622 | 998 | 1,341 | 506 | ..... |
| Christmas Island (d) | 102,437 | 93,335 | 110,000 | 260,000 | 197,982 | 310,625 | 250,000 | 300,000 |
| Dutch W. Indies | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Aruba | 23,690 | 25,531 | 36,036 | 29,061 | 27,227 | 27,838 | ..... | ..... |
| Curacao | ..... | 1,100 | ..... | ..... | ..... | 3,570 | ..... | ..... |
| Egypt | ..... | ..... | ..... | 700 | 1,000 | 2,397 | 6,425 | 69,958 |
| France | 476,720 | 469,408 | 375,000 | 485,607 | 397,908 | 333,506 | 312,204 | ..... |
| French Guiana | 6,595 | 6,795 | 10,565 | 9,092 | 8,997 | 6,816 | ..... | ..... |
| Makatea (d) | ..... | ..... | ..... | ..... | ..... | ..... | 12,000 | 40,000 |
| Norway | 2,522 | 3,482 | 1,830 | 1,771 | 1,364 | 903 | ..... | ..... |
| Ocean & Nauru Islands | 108,615 | 140,000 | 190,000 | 301,160 | 197,922 | 310,625 | 250,000 | 300,000 |
| Russia | 20,585 | 13,891 | 16,774 | 19,660 | 21,313 | 24,867 | 25,486 | ..... |
| Spain | 1,370 | 1,300 | 3,078 | 4,483 | 1,387 | 2,840 | (d) 3,520 | ..... |
| Sweden | (c) | (c) | 5,317 | (c) | (c) | ..... | ..... | ..... |
| Tunis | 559,645 | 796,000 | 1,069,000 | 1,300,500 | 1,223,512 | 1,286,262 | (a) 1,446,633 | 1,923,000 |
| United States | 2,135,449 | 2,085,586 | 2,251,459 | 2,413,032 | 2,503,186 | 2,734,849 | 3,268,626 | 3,216,046 |

(b) Metric tons of phosphate of lime; in addition there were 315,200 cu. m. of phosphatic chalk in 1902, 350,250 cu. m. in 1903, 311,640 cu. m. in 1904, 80,380 cu. m. in 1905, and 119,450 cu. m. in 1906. (c) Statistics not available. (d) Figures furnished by Charles Michel, Paris. (e) Exports.

*Algeria and Tunis.*—The largest producer in North Africa is the Société des Phosphates de Gafsa. Its production was 1,312,378 tons in 1912, 1,121,759 tons in 1911, and 950,000 tons in 1910. The company has options on all the deposits in the district. Other companies are the Société des Phosphates Tunisiens, the production being 300,000 tons in

[1] R. N. Bell.

1912. This company has taken over the deposits at Meheri Zebbeus on a royalty of 77 cents per ton. The Compagnie des Phosphates de Constantine produced about 300,000 tons in 1912. All these concerns are increasing their outputs.

The Compagnie du Dyr produces about 130,000 tons, which can be increased to 200,000 tons, and has recently sold one of its unworked deposits at Kef Rebiba to the Compagnie de Saint Gobain. This deposit is estimated to yield over 100,000 tons yearly. In Tunis deposits exist at M'Zaita, from which 300,000 tons a year can be obtained, and at Djebel Onk. A large factory for the manufacture of phosphate has been established close to the city of Oran, Algeria.

According to Mr. Molinos, president of the phosphate company at Gafsa, the following is the phosphate consumption in Europe since 1900: In the second year of operations, which is 1900, the European consumption was 1,645,000 tons. Of this we have furnished 171,000 tons, and the United States 600,000 tons. In the following 5 years from 1905 to 1910, the European consumption rose to 3,400,000 tons, from an amount of 2,560,000 tons. At the end of this period we furnished 950,000 tons, and the United States 1,100,000 tons. From 1910 to 1912, the consumption passed from 3,400,000 tons to 4,183,000 tons. Gafsa exported 1,312,000 tons in the last year. The annual increase of European consumption which before 1910 was 220,000 tons per year, is now 390,000 tons, but there have been so many variations during this period that it is not possible to predict at what rate the consumption will rise.

The following table gives the shipments of rock from Algeria and Tunis:

SHIPMENTS OF PHOSPHATE ROCK FROM ALGERIA AND TUNIS.
(In metric tons.)

| Year. | Algeria. | Tunis. | Year. | Algeria. | Tunis. |
|---|---|---|---|---|---|
| 1895 | 104,603 | ..... | 1904 | 344,969 | 457,133 |
| 1896 | 142,524 | ..... | 1905 | 347,747 | 529,645 |
| 1897 | 227,870 | ..... | 1906 | 302,262 | 747,303 |
| 1898 | 269,572 | ..... | 1907 | 343,085 | 956,998 |
| 1899 | 286,681 | 65,209 | 1908 | 362,890 | 1,270,020 |
| 1900 | 277,896 | 171,288 | 1909 | 351,491 | 1,224,822 |
| 1901 | 278,185 | 178,019 | 1910 | 319,069 | 1,286,262 |
| 1902 | 265,964 | 266,553 | 1911(a) | 332,897 | 1,446,633 |
| 1903 | 301,112 | 360,621 | 1912(a) | 388,515 | 1,923,000(e) |

(a) Figures furnished by Charles Michel, Paris. (e) Estimate.

The value of the phosphate exported from Algeria, was $2,005,899 in 1910, and $2,117,596 in 1911.[1]

More than one-third the North African production goes to France, contracts for the output are made a year in advance.

[1] *Dly. Conslr. and Tr. Rep.*, Oct. 4, 1912.

In 1911 the production of Algeria and Tunis was distributed as follows:

| | |
|---|---|
| Germany | 433,063 tons |
| England | 214,127 tons |
| Spain | 119,667 tons |
| France | 623,055 tons |
| Italy | 382,807 tons |
| Others | 6,811 tons |

*Australia.*—Phosphates occur in York Peninsula, South Australia, in Cambrian limestone. The analyses of samples and localities are given in the Record of the Mines of South Australia, 4th edition, p. 334, 1908, by H. Y. L. Brown, F. G. S., government geologist.

*Belgium.*—In Belgium the manufacture of phosphate is important on account of cheap sulphuric acid and the large demand for fertilizers. Of thirty-three superphosphate factories sixteen manufacture their own acid. The industry centers around Antwerp, owing to transportation facilities. The phosphate rock deposits are low grade. The rock near Liege and Mons, contains less than 50 per cent. tricalcium phosphate; near Baudour deposits averaging 60 per cent. are encountered.

The practice is to mix the low-grade Belgium phosphate with the high-grade imported ones. Most of the imported phosphates come from Algiers and Tunis and the islands of the Pacific. In addition, about 65,000 tons of Florida phosphate is used annually and a small amount comes from Somme in France. A small import also comes from Aruba, West Indies. The foreign phosphates cost from $9.60 to $11.60 per ton, while the native rock ranges from $4.80 to $5.80 per ton.

The treatment of the rock in general, is with 53° Baumé-acid, although some works employ weaker waste acid used in purifying coal tar. The process does not vary much from what is used in the best German factories. Crushers of the American Griffin type are much used. The mixers are mostly of the vertical type, 3 ft. 3 in. height and 9 ft. 10 in. in diameter. The mixers are in duplicate, emptying into adjoining cellars. The fumes are used for sodium fluosilicate. As a rule, the hot superphosphate from the cellars is mixed with 5 per cent. of rich phosphate. This dries the product and reduces the moisture. The crushers are on the ground floor; the ground phosphate being elevated to upper floors where the mixers are located. The men are paid according to tonnage and not by the day.

To show the rapidity of increase of the phosphate industry in Belgium, the output rose from 1903 to 1910, from 230,000 tons to 540,000 tons, which at that time was 6 per cent. of the world's production. In 1910 the export trade was net 276,240 tons. An analysis of this export trade for 1910, is given in the following table.

| o— | Metric Tons. | To— | Metric Tons. | To— | Metric Tons. |
|---|---|---|---|---|---|
| ..... | 119,900 | United States..... | 4,100 | India..... | 950 |
| ..... | 60,000 | Switzerland..... | 2,700 | Australia..... | 600 |
| ..... | 57,000 | Dutch colonies..... | 2,500 | Natal..... | 500 |
| ds..... | 54,900 | Sweden..... | 2,200 | Mexico..... | 200 |
| ain..... | 19,900 | Egypt..... | 1,600 | Cape Colony..... | 100 |
| ..... | 19,500 | Russia..... | 1,200 | Brazil..... | 40 |
| ..... | 4,600 | Austria-Hungary... | 1,000 | | |

ıddition to superphosphate rock, there is an annual production of ıs of bone-superphosphate made in one factory, and the output ) France. In addition, 400 tons of superphosphate made from charcoal from the sugar works, is used locally.

Burght, a large factory produces soluble guano. The imports of guano from Peru, amount to 15,300 tons per year, and from West 3000 tons per year. The product goes to Germany and the lands.

ificial guano is made from raw material, such as leather waste e refuse from fish-preserving works.

e value of Thomas slag, as a fertilizer, was first recognized in m and the industry is a large one. The grinding is performed in all mills. These are long horizontal cylindrical mills which origi- in Denmark. The ground material is of an average diameter of m., 75 per cent. passing the corresponding mesh. The raw material ıined from seven steel works that use the basic process, and also 00,000 tons of imported slag from France. The number of estab- nts grinding slag is eleven, five being steel works. It is estimated 00 men are occupied in the preparation of Thomas meal, and the ry requires about 2000 h.p. The Belgium consumption is about 0 tons a year, while the export in 1910, was 521,500 tons with an e value of $8.59. The distribution of Thomas meal is given in lowing table:

| untries. | Metric Tons. | Countries. | Metric Tons. | Countries. | Metric Tons. |
|---|---|---|---|---|---|
| ..... | 330,300 | France..... | 15,400 | Portugal..... | 4,200 |
| ..... | 45,700 | United States..... | 9,000 | Australia..... | 2,700 |
| ..... | 29,100 | Spain..... | 7,600 | Austria-Hungary... | 2,100 |
| nds ..... | 23,700 | India..... | 4,900 | Cape Colony..... | 1,700 |
| itain..... | 21,400 | Sweden..... | 4,500 | Dutch colonies..... | 1,700 |

r comparison the German net exports in 1911 of this product, were ) tons.

ıe values of exports from Antwerp, Belgium, of Basic slag, etc., to ıited States, are as follows:[1]

[1] . *Conslr. and Tr. Rep.*, March 7, 1913.

| Basic Slag. | Bones, Bone-meal, Waste, etc. | Fertilizers. |
|---|---|---|
| 1911, $19,632..... | 1911, $29,407 | 1911, $636,445 |
| 1912, $43,729..... | 1912, $35,594 | 1912, $441,017 |

*Curaçoa.*—No production has been made from the Santa Barbara estate since 1883. An agreement between owners, however, may be satisfactory and resumption of exports is probable.

*Egypt.*—Exploitation continues 45 miles north of Kosseir near Safagna, a deserted region. A short railway runs to the mine at Om El Honetat. The work is underground. About 300 tons per day are produced at a selling price of 26 shillings per ton. The phosphate is said to be of equal quality to that of Florida or Tunis. The product goes to China and Japan as the transit through the Suez Canal is prohibitive. The company has paid dividends for 3 years. An Italian company has also been formed to exploit phosphates in Egypt.

The output phosphate rock was 700 tons in 1908, 1000 tons in 1909, 2,397 tons in 1910; 6,425 tons in 1911 and 69,958 tons in 1912.[1]

According to Mr. Polie, in the *Bulletin de la Societe d'Encouragement* phosphates deposits have been recognized at Esneh in the Nile Valley, at Safadja on the Red Sea, and at Rachid in the Oasis of Daklah.

*France.*—Agricultural requirements are normal. About 75 factories manufacture approximately 1,600,000 tons of superphosphate annually. Including the sulphuric acid plants required, 20,000 men are employed. The capital invested is about 200,000,000 francs. A profit of 5 per cent. on the investment can hardly be realized on the average unless a profit of 6 francs is made per ton. The consumers of American crude phosphate paid approximately $6.95 per metric ton during 1912; and $6.20 in 1911. No import duty exists. The imports are as follows:[2]

| From— | 1910, Metric Tons. | 1911, Metric Tons. | 1912, Metric Tons. |
|---|---|---|---|
| Tunis..... | 516,564 | 549,080 | 703,872 |
| Other countries..... | 171,109 | 191,276 | 199,617 |
| Total weight..... | 687,673 | 740,356 | 903,489 |
| Total value..... | $4,300,619 | $4,594,285 | $5,579,823 |

In 1911 the imports were distributed as follows:

United States, 133,491 tons; Belgium, 16,342 tons; Egypt, 3280 tons; other foreign countries, 2219 tons; Algeria, 34,292 tons; Tunis, 549,081 tons; other French colonies, 1652 tons.

[1] Report to the Egyptian minister of finance, 1913.
[2] Consul General Memminger, Paris.

The imports of phosphates into Marseille, France, in 1911, were 23,709 tons; in 1912, 37,733 tons. Marseille received during 1912, 34,856 tons from Tunis; 2243 tons from Algeria; none from the United States. The imports in Cette in 1911, were 43,292 tons of natural phosphate, and in 1912, 54,182 tons. Of these quantities 9260 tons and 15,185 tons, came respectively from the United States. The phosphates exported from Algeria according to the reports from dealers, were valued at $2,117,596 in 1911, and $2,236,870 in 1912.

In January, 1913, quotations for immediate delivery were as follows per unit of phosphate per long ton, c. i. f. Marseille: For Gafsa (Tunis) phosphate, 58–63 per cent., 11.1 cents; Algerian phosphate, 63–68 per cent., 12.2 cents, 58–63 per cent., 10.4 cents; Florida rock, 77–82 per cent., 14 cents; Tennessee, 78–80 per cent., 14 cents; pebble, 70 per cent., 11.5 cents; 75 per cent., 13.8 cents.

*Germany.*—Natural phosphates are imported into Germany in large quantities, the most recent statistics being as follows:[1]

| Imported from— | 1911, Metric Tons. | 1912, Metric Tons. |
|---|---|---|
| United States | 378,770.4 | 342,646.3 |
| Algeria | 164,691.9 | 190,747.9 |
| Tunis | 62,267.1 | 115,206.1 |
| Belgium | 91,265.9 | 63,011.0 |
| Christmas Islands | 63,778.6 | 52,015.9 |
| Australia | 20,804.3 | 49,248.1 |
| German Australasia | 17,005.3 | 44,257.7 |
| France | 15,681.9 | 40,686.4 |
| Other countries | 18,994.2 | 5,024.8 |
| Total | 833,259.6 | 902,844.2 |
| Total value | $9,915,794 | $10,743,796 |

The decline in importations from the United States since 1908 is said to be due to the fact that the rock now arriving from the Christmas Islands, and which is comparatively new in this market, contains 85 to 86 per cent. basic phosphate of lime, as against a lower degree in the case of Florida and Tennessee phosphates, which run from 77 to 80 per cent. As stated by one importer the requirements for Tennessee phosphate are 76 to 80 per cent. minimum basic calcium phosphate; iron and alumina must not exceed 3 to 4 per cent. and 2 per cent. on the phosphate limit is deducted for each 1 per cent. iron and alumina.

*Ocean Island.*—The Pacific Phosphate Co., Ltd., has two shipping settlements on the Island, Ooma and Tapiwa. At the former modern machinery is used.

The deposits of the Pacific are estimated roughly to contain 130,000,000 tons of rock, Christmas Island has another 25,000,000 tons.

[1] Consul General Robert P. Skinner, Hamburg.

*Peru.* Guano.—During the year ending March 31, 1912, 36,300 metric tons of guano were exploited by the Compañía Administradora del Guano, which collects all the guano for consumption in the Republic. According to official statistics, the guano exports from Peru, all of which are handled by the Peruvian Corporation (Ltd.), were as follows during the calendar year 1911:

| Exported to— | Metric Tons. | Value. |
|---|---|---|
| Great Britain | 36,535 | $716,720 |
| Belgium | 24,240 | 472,195 |
| Germany | 6,700 | 130,516 |
| France | 2,112 | 41,142 |
| Total | 69,587 | 1,360,573 |

Guano exported from Valparaiso, Chile, to the United States in 1911 was valued $1611. Dr. H. O. Forbes, ornithologist will report early in 1913 on measures to prevent the destruction of birds.

*Society Islands.*—In 1912 the growing trade in phosphate (Papeete, Tahiti Island) was in exports of natural phosphate 38,488 tons worth $148,584; in 1911, 11,911 tons valued $35,983. In 1912, 914 metric tons of phosphate were shipped to the United States and Hawaii, 8994 tons to England, 6100 tons to Germany and 1279 tons to New Zealand and Australia.

*Russia.*—Fertilizers are imported in large quantities by the three Baltic Provinces, Germany supplying nitrate of soda, kainit, and potash salts and a large proportion of the imports of superphosphate of lime. The latter article is also obtained from the United Kingdom and Sweden. Basic slag is imported from Belgium and the United Kingdom.

Prices of fertilizers at Riga were as follows: Superphosphate of lime, $14.69 per ton for 13 to 14 per cent., and $17.09 per ton for 16 to 18 per cent. phosphoric acid; basic slag, $12 per ton for 17 per cent. phosphoric acid; acid, kainit, $9.60 per ton; nitrate of soda, $54.47 per ton; potash salts, $21.36 per ton (containing 30 per cent. potash).

The production of superphosphates in Russia in 1911, was about 7,500,000 poods; plus the imports of 9,425,000 poods gives a total of 17,000,000 poods consumed (278,700 metric tons.) In 1908 this was estimated at 6,000,000 poods. Much of the acid is by-product acid from Silesia; but the superphosphate is also made in Germany and exported to Russia. One-third the fertilizers of all kinds used in Russia is consumed in the Livonia and Courland Governments, where annually 4,000,000 poods are required. Mineral manures are not used in the southwest, and very little central and northern European Russia.

The phosphorite deposits of Kostrom, Smolensk and Kazan are not being worked on a large scale. One factory the Kineshma Chemical works is said to be working the Kostrom phosphates by the aid of Ural pyrites. The capacity of two other factories in the southwest is about 2,000,000 poods; the Podolia phosphates are to be used.

Custom house statistics of imports are as follows:[1]

| | 1909, Poods. | 1910, Poods. | 1911, Poods. |
|---|---|---|---|
| Mineral Phosphorites | 1,414,000 | 1,520,000 | 1,770,000 |
| Other Nat. Fertilizers | 3,000 | 67,000 | 353,000 |
| Unground Thomas Slag | 305,000 | 125,000 | 11,000 |
| Crude Ground Bones | 27,000 | 16,000 | 11,000 |
| Ground Thomas Slag | 5,641,000 | 7,899,000 | 8,513,000 |
| Superphosphates | 4,589,000 | 7,359,000 | 9,425,000 |
| Bones treated with Sulphuric Acid | 9,330 | 20,000 | 21,000 |
| Roasted Bones | 2,100 | 2,900 | 2,600 |
| Stassf't Salts, German | 2,347,000 | 3,087,000 | 4,155,000 |
| Chloride of Potassium | 154,000 | 965,000 | 177,000 |
| Chile Saltpeter | 955,000 | 1,744,000 | 1,936,000 |

The bone dust exported from Russia in the European Caucasus, and Finland, was valued at $852,840 in 1910, and $693,705 in 1911.[2]

*Spain.*—Three mines produced 3520 tons of phosphate in Spain in 1911; the rock was valued at 92,274 pesetas at the mine. The consumption of fertilizers is as follows:[3]

| | 1911. | 1912. |
|---|---|---|
| Imported nitrate of soda | 42,415 tons | 45,701 tons |
| Imported superphosphate and Thomas slag | 258,562 tons | 160,547 tons |
| Other fertilizers | 99,032 tons | 91,855 tons |
| Sulphate ammonia | 14,000 tons | 15,000 tons |
| Phosphate of lime equivalent in superphosphate made in Spain | 294,570 tons | 317,129 tons |

The superphosphate manufacture has therefore increased 22,560 tons.

The import duty on phosphate rock is about 5 cents a metric ton; on imported fertilizers, from 9.6 to 19.3 cents per metric ton.

*Other Countries.*—In Japan the production of phosphate in the Nagasaki consular district for 1911 is reported as 3,078,025 lb. valued at $11,743.[4]

The fertilizer exported from Mexico City to the United States during the year 1910 was valued at $41,707; during the year 1911 at $59,572.[5]

In the Netherlands six factories make superphosphates and mixed

[1] *American Fertilizer*, Nov. 16, 1912
[2] Consl. Gen'l., John H. Snodgrass, *Dly. Consls. and Tr. Rep.*, Sept. 25, 1912.
[3] Revista Minera.
[4] Cons. Carl F. Dieckman, *Dly. Consls. and Tr. Rep.*, Oct. 14, 1912.
[5] Consul General, Arnold Shanklin, *Dly. Consls. and Tr. Rep.*, Jan. 29, 1319.

fertilizers. Nearly all of these are on the seaboard, and treat raw phosphates from the United States, Africa and the Pacific. The output is estimated at 306,000 metric tons per year. The manufacture of ammonium superphosphate is on the increase. The standard product obtained by mixing ammonium sulphate with ordinary superphosphate contains 7 per cent. of nitrogen and 9 per cent. soluble acid phosphate.

The Italian Government is to make researches on the phosphate deposits of Tripoli in four or five regions.

In Sweden superphosphate is now available for export, the domestic demand being supplied by manufacture in the country. The imports of phosphate into England are chiefly from Tunis and the United States. In 1911 the former country imported 183,759 tons, and the latter 175,148 tons. The total imports were 493,415 tons. The exports of chemical manure from Portuguese East Africa in 1912 were as follows: Lourenco Marques, $6664; Inhambane, $8298.

## Technology

*Palmaer Process.*—Prof. W. Palmaer proposes the use of perchloric acid for dissolving the bone phosphate; the acid is electrolytically regenerated. A solution of sodium perchlorate is electrolyzed in a diaphragm cell, producing perchloric acid at the anode and sodium hydrate at the cathode. The anode solution is used for leaching, the leach partly neutralized with one-half the cathode solution to precipitate the bicalcic phosphate. Flue gas is used to convert the remainder of the cathode alkali into carbonate; the filtrate from the phosphate is precipitated with this as calcium carbonate, regenerating the solution remaining as sodium perchlorate. Hydrogen is a by-product.

The cost of power determines the feasibility of the process with waste tailings containing apatite; lime carbonate is a detriment as power is wasted. The extraction from bone phosphate is 98 per cent. The process is intended to treat materials not now treated by sulphuric acid commercially. Bicalcic phosphate has been produced as a by-product by treatment of bones with hydrochloric acid. Germany and France each produced about 5000 tons in 1910.

*Newberry Fishburne Process.*—Spencer B. Newberry, well-known as expert in cement manufacture, has made experiments to determine the effect of calcination on ordinary phosphate rock. Patents have been taken out for a process which has been invented to produce a product containing a very high percentage of citric-acid soluble phosphate. According to experiments made at some of the agricultural experiment

[1] *Eighth Intl. Congr. Appl. Chem.*

, such material would be perfectly satisfactory in many cases
tilizer. It is possible that further experiments may show the
ion of this material in a large number of cases where the present
ate is being used.

process consists in treating the phosphate rock, together with
ert substance such as sulphate of lime or sulphate of soda, at a
t. This produces a quick action in the kiln and the citric acid
phosphate is obtained in highly concentrated form. Alkali salt
driven off at a higher temperature after the first operation.
e ordinary superphosphate process, while much of the phosphate
ned in water soluble form, the whole mixture is diluted with sul-
f lime which is not separated. In the Newberry product, the
vailable phosphoric acid percentage is twice as great as in the
osphate. The patents for this process have also been granted
ium, Great Britain, France, Germany and foreign countries.
oduct is very similar apparently to the Thomas slag so largely
Europe. If the process proves successful as far as the marketing
roduct goes, it will effect a tremendous saving in transportation
, and also do away with a large consumption of sulphuric acid.
id that the first plant has been erected in Tennessee and that a
y financing the process has a capital of $30,000,000.

*mas Slag.*—According to recent researches[1] tricalcium phosphate
to 1100° C. largely loses its solubility in citric acid, and regains it
ing melted. The most soluble product is obtained when sufficient
present to form tricalcium phosphate. An excess forms tetra-
phosphate, which is insoluble. This condition may be corrected
ng silica.

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# PLATINUM

By Frederick W. Horton

The production of refined platinum from crude metal of domestic rigin in the United States in 1912 was approximately 1000 troy oz., alued at $45,550 as compared with 927 oz., valued at $40,058 in 1911. .s in previous years the output was derived almost entirely from the lacer deposits of northern California and Oregon where the crude latinum is recovered as a by-product in mining gravels and beach sands or gold. Perhaps one-third of the platinum thus derived is separated om the accompanying gold by the miner and is marketed as crude latinum, but the bulk of the output is recovered by the United States int and private refiners from the gold dust and bullion sent them from the ove-mentioned districts. Probably more than 80 per cent. of the total itput is derived from dredging operations in Butte, Yuba and Sacra- ento Counties, California; and about 15 per cent. from hydraulic ines in Trinity, Shasta, Humboldt, and Siskiyou Counties, California, id from Josephine and Jackson Counties, Oregon; and the remaining 5 er cent. from the beach sands in Del Norte and Humboldt Counties, alifornia, and Coos and Curry Counties, Oregon. As far as is known iere was no production of platinum from lode mines in 1912. Neither ie Rambler mine at Holmes, Wyoming, nor the Key West and Great astern prospects in Clark County, Nevada, made any production. urther, all operations at the Rambler property, which in 1911 shipped veral car loads of ore to the Baltimore Smelting Rolling Co., at Balti- iore, Maryland, with what seemed promising results, have been discon- nued, and the contemplated erection of a mill put off indefinitely.

While the production of platinum in the United States is almost a egligible quantity in comparison with the domestic consumption, the efining of crude platinum and the manufacture of platinum wares of all escriptions is a business of considerable importance. During the year nded June 30, 1912, 52,165 oz. of crude platinum, valued at $2,012,267 ere imported. Probably more than 85 per cent. of this crude metal as Russian platinum, but none of the material was received directly om Russia, shipments being made through firms in England, Germany, nd France. The accompanying table shows the amount, value and ource of platinum imported during the year ended June 30, 1912.

It may be noted that while the largest imports of crude platinum ere from England and the largest imports of ingots, bars, plates, and

manufactured forms from France, Germany led in the value of total imports.

IMPORTS OF PLATINUM INTO THE UNITED STATES DURING THE YEAR ENDED JUNE 30, 1912

| Country. | Crude Platinum. | | Ingots, Bars, Plates, Etc. | | Crucibles, Retorts and Vessels for Chemical Use. | Total Value. |
|---|---|---|---|---|---|---|
| | Troy Oz. | Value. | Troy Oz. | Value. | Value. | |
| England | 19,951 | $819,507 | 19,169 | $ 803,742 | $ 5,985 | $1,629,234 |
| Germany | 15,335 | 576,719 | 22,673 | 972,970 | 88,276 | 1,637,965 |
| France | 10,178 | 394,211 | 25,723 | 1,041,267 | 64,087 | 1,499,565 |
| Colombia | 6,627 | 219,128 | ..... | ..... | ..... | 219,128 |
| Canada | 45 | 1,641 | 777 | 23,792 | ..... | 25,433 |
| Other countries | 29 | 1,061 | 4 | 160 | 1,293 | 2,514 |
| Total | 52,165 | $2,012,267 | 68,346 | $2,841,931 | $159,641 | $5,013,839 |

In addition to the foreign crude platinum refined in this country in 1912, there were at least 20,000 to 25,000 oz. of platinum refined from scrap of domestic origin. With the exception of a few companies which refined scrap in a small way, the refiners of platinum in the United States are: The Bureau of the Mint; Baker & Co., Inc., Newark, N. J.; Croselmire & Ackor, Newark, N. J.; S. S. White Dental Mfg. Co., Prince's Bay, N. Y.; American Platinum Works, Newark, N. J.; Roessler & Hasslacher Chemical Company, Perth Amboy, N. J.; and J. Bishop & Co., Malvern, Penn.

A comparative statement of the production, imports, and consumption of platinum in the United States for a series of years is given in the accompanying table. It will be noted that in 1912 there was a marked fa ling off in both the weight and value of platinum imported as compared with that in 1911.

STATISTICS OF PLATINUM IN THE UNITED STATES.

| Year. | Production. (a) | | Imports. | | | Consumption. |
|---|---|---|---|---|---|---|
| | | | Unmanufactured. | | Manufactured. | |
| | *Troy Oz.* | *Value.* | *Troy. Oz.* | *Value.* | *Value.* | *Value.* |
| 1897 | 150 | $ 900 | 83,080 | $ 960,299 | $ 43,921 | $1,005,120 |
| 1898 | 225 | 3,375 | 101,018 | 1,178,142 | 52,283 | 1,233,800 |
| 1899 | 300 | 1,800 | 187,778 | 1,462,157 | 55,753 | 1,539,710 |
| 1900 | 400 | 2,500 | 118,919 | 1,728,777 | 36,714 | 1,767,991 |
| 1901 | 1,408 | 27,526 | 85,438 | 1,673,713 | 24,482 | 1,725,721 |
| 1902 | 94 | 1,814 | 105,450 | 1,950,362 | 37,618 | 1,989,794 |
| 1903 | 110 | 2,080 | 114,521 | 1,921,772 | 135,889 | 2,059,741 |
| 1904 | 200 | 4,160 | 103,802 | 1,812,242 | 105,636 | 1,920,478 |
| 1905 | 318 | 5,320 | 104,196 | 1,985,107 | 188,156 | 2,176,263 |
| 1906 | 1,439 | 45,189 | 137,556 | 3,601,021 | 187,639 | 3,797,460 |
| 1907 | 357 | 10,589 | 74,208 | 2,509,926 | 175,651 | 2,696,166 |
| 1908 | 750 | 14,350 | 50,768 | 1,096,615 | 134,119 | 1,244,984 |
| 1909 | 638 | 15,950 | 118,851 | 2,557,574 | 410,997 | 2,984,521 |
| 1910 | 773 | 25,277 | 120,478 | 3,320,699 | 333,965 | 3,679,941 |
| 1911 | 929 | 40,058 | 122,390 | 4,722,752 | 135,842 | 4,898,652 |
| 1912 | 1,000 | 45,550 | 104,683 | 4,334,488 | 159,995 | 4,540,033 |

(a) Statistics of the U. S. Geol. Surv., except for 1911 and 1912.

*Market.*—During the first week in January refined platinum was quoted in New York at $46 per ounce and hard metal containing 10 per cent. iridium at $48.50 per ounce. Trade was dull as is usual after the holiday season but there was no falling off in prices until the middle of February when they declined to $45.50 and $48 per ounce for refined and hard metal, respectively. Prices remained at these quotations for the remainder of the year, the market being quiet and featureless until late in September when there was a brisk demand by the jewelry trade and business was good throughout the fall. The average price of refined platinum for the year was $45.55 per ounce as compared with $43.12 in 1911, an advance of nearly 6 per cent. In itself this increase in price would not be particularly notable, did it not top a series of still greater advances during the preceding three years. In August, 1908, the average price of platinum in New York was $18.75 per ounce and some lots were offered as low as $17.50. The average price for that year was $22.85 per ounce, while in 1912 it was $45.55, an advance of over 99 per cent. in 4 years. This enormous increase was due almost entirely to the large demand for platinum for jewelry, and although the present high price of the metal has undoubtedly restricted its use in other directions, this restriction has been small and has not affected the market to any noticeable degree. In view of the limited production and an evident control of the market by the large refiners, in the event of a good demand even higher prices may be expected in 1913.

The accompanying table shows the average monthly prices of platinum at New York since January, 1906.

AVERAGE MONTHLY PRICES OF PLATINUM AT NEW YORK.
(In dollars per troy ounce.)

| | 1906 | 1907 | 1908 | 1909 | 1910 | 1911 | 1912 |
|---|---|---|---|---|---|---|---|
| January.. ... | 20.50 | 38.00 | 25.50 | 24.10 | 29.00 | 39.06 | 46.00 |
| February. ... | 25.00 | 38.00 | 25.50 | 24.00 | 28.75 | 39.31 | 45.63 |
| March..... | 25.00 | 37.00 | 25.50 | 23.75 | 29.13 | 41.00 | 45.50 |
| April..... ... | 25.00 | 32.50 | 23.50 | 23.50 | 29.25 | 41.35 | 45.50 |
| May..... | 25.00 | 29.50 | 22.50 | 23.25 | 29.55 | 42.81 | 45.50 |
| June..... | 25.40 | 26.20 | 23.50 | 22.75 | 31.38 | 42.88 | 45.50 |
| July..... | 26.00 | 26.75 | 20.00 | 22.43 | 33.00 | 42.95 | 45.50 |
| August..... | 26.00 | 28.13 | 18.75 | 22.65 | 33.00 | 44.38 | 45.50 |
| September.... | 32.10 | 28.70 | 20.00 | 25.31 | 33.63 | 45.31 | 45.50 |
| October..... | 33.00 | 27.13 | 21.50 | 27.75 | 37.50 | 46.25 | 45.50 |
| November.... | 35.50 | 26.31 | 24.00 | 29.50 | 39.44 | 46.13 | 45.50 |
| December..... | 38.00 | 26.00 | 24.00 | 29.50 | 38.75 | 46.00 | 45.50 |
| Year..... | 28.04 | 28.18 | 22.85 | 24.87 | 32.70 | 43.12 | 45.55 |

## Platinum in Foreign Countries

*Australia.*—A few hundred ounces of platinum are produced annually from gravel deposits at Platina, in the Fifield district, New South Wales

In 1911 exports of the crude metal (practically equal to the production) amounted to 470 oz. valued at £2999 as compared with 332 oz. worth £1418 in 1910. The increase in production was directly due to the higher prices received for the metal which permitted the working of lower-grade gravels than had heretofore been mined. The gravel bed in which the platinum is found is only six to eight inches thick and is covered by 50 to 60 ft. of barren gravel. Gold is found with the platinum, the proportion being about 1 part gold to 7 parts platinum. The total production to 1912 was 12,380 oz. valued at £25,130.

*Canada.*—The principal locality in Canada from which platinum is derived is the Sudbury district of Ontario. Here the metal occurs in conjunction with palladium in the nickeliferous pyrrhotite and chalcopyrite ores of the district. It is found combined with arsenic, forming an arsenide of platinum ($PtAs_2$) known as sperrylite. The platinum together with the palladium is recovered from the electrolytic muds obtained by refining the mattes derived from the copper-nickel ores. It is impossible to determine the amount of platinum produced from this source, as the mattes are largely exported to the United States and Great Britain for refining and the electrolytic muds obtained from them are often mixed with muds from other lots of metal. The following figures, however, may be of interest:

During the six years from 1907 to 1912, inclusive, the Orford Copper Works, of Constable Hook, New Jersey, which refines the greater part of the nickel-copper mattes produced from the Ontario ores, recovered 2864 oz. of platinum and 4896 oz. of palladium.[1] It cannot be specifically stated that this metal all came from the Ontario nickel-copper ores, as mattes derived from ores from other localities were also treated at the plant, but it is certain that by far the largest part of the output may be credited to the Ontario mines.

The only other districts in Canada making any production of platinum are the Tulameen and Samilkameen districts of British Columbia, which are credited with a total yield of from 15,000 to 20,000 oz. of the metal since it was discovered in the province. However, the output from these districts reached a maximum about 20 years ago, and at present the production has declined to almost nothing. In 1912 the yield from these districts is estimated at not more than 30 oz. During the year several parties of prospectors and engineers visited these districts to investigate the possibilities of reviving the platinum industry. Among the companies represented was the firm of Johnson & Mathey, of London, whose agents conducted an extensive examination of the bench gravels

[1] *The Canadian Min. Journ.*, March 15, 1913.

of the Tulameen River. To date, however, no active work has been undertaken.

During the year frequent mention was made in the technical press of the purported finding of platinum in certain dikes in the vicinity of Nelson. The publication of these reports resulted in considerable excitement in the immediate vicinity of Nelson, but the platinum boom was proved to be without foundation by William Fleet Robertson, the provincial mineralogist, by the simple expedient of having samples from the various dikes which were supposed to carry platinum sent to reputable assayers for analysis. The samples proved to be barren.

*Colombia.*—The output of crude platinum in Colombia during 1912 is estimated at 11,750 oz. as compared with about 10,000 oz. in 1911. Practically the entire production was from the Choco district, which is situated between the Atrato river and the Pacific coast, and most of it was won by natives using primitive methods. The increase in output was largely due to the stimulation of high prices and to the unusual amount of attention given during the year to the platinum-bearing gravels. It will be noted from the accompanying table, which shows the quantity and value of the crude platinum imported into the United States from Colombia for a series of years, that in 1912 there was an increase of more than 1100 oz. over the amount imported during 1911. Most of the platinum mined finds its way into the hands of storekeepers at Quibdo who send the greater part of it to the banks at Cartegena which acting in the capacity of commission merchants export the crude metal largely to the United States and Great Britain.

UNITED STATES IMPORTS OP PLATINUM FROM COLOMBIA.
(In troy ounces.)

| Year. (a) | Quantity. | Value. |
|---|---|---|
| 1907 | 5,496 | $100,206 |
| 1908 | 1,092 | 25,576 |
| 1909 | 2,392 | 36,440 |
| 1910 | 1,600 | 31,383 |
| 1911 | 5,503 | 147,820 |
| 1912 | 6,627 | 219,128 |

(a) Fiscal year ending June 30.

The great demand for platinum, coupled with the possibility of a monopoly by the Russian government, promises an extensive development of the platiniferous deposits of Colombia in the near future. Many engineers representing foreign capital investigated properties during 1912, and several substantial companies have already acquired interests. Besides the Consolidated Goldfields, which obtained an interest in the La Lozana and other platinum mines last year, the

Colombian Goldfields Limited, of London, purchased important properties in 1912 and prepared for the installation of a plant. In August, the Timbiqui Company purchased the San Juan alluvial mine and proposes to install a plant at an early date. A French company purchased the Gagui river concessions and contemplates the erection of a dredge. The Certigui Mining Company, of New York, operated a 5 cu. ft. steam-driven Empire dredge on the Certigui river, a tributary of the Atrato, above Quibdo during the latter part of the year. The officers of the company report that 22,700 cu. yd. of gravel were mined with a yield of about $2500 in platinum and $5000 in gold. These results were considered so promising that the company anticipates the installation of a larger and more modern dredge. The Certigui company was the only one carrying on dredging operations for platinum during the year.

The Breitung Mines Corporation had options on several tracts on the Cauca and Nechi rivers and did considerable prospecting by drilling in 1912. Lewisohn Brothers prospected an area in the Atrato valley early in the year, but it is understood with unsatisfactory results. The Goldfield American Development Company, Limited, outfitted a party to drill several claims at Novita, on the Condoto river, a tributary of the San Juan.

Explorations and washing tests on the Cimarronas river have proved the deposits of platiniferous gravels to be much greater than was at first thought. It is said that this field is likely to prove more important than the districts on the Condoto and the tributaries at the headwaters of the San Juan, as it has more extensive dredging areas and better transportation facilities. Most of the gravel in the district carries gold, and in some cases it is said enough to pay operating expenses.

The completion of the Panama Canal will bring the west coast of Colombia within nine days' travel of New York, and will doubtless serve as a great stimulus to platinum mining in the country.

*Russia.*—The platinum production of Russia in 1912 is estimated at 300,000 oz. as compared with 280,000 oz. in 1911. The increase in output was due to the high price of the metal and a plentiful supply of labor. Moreover, exceptional weather conditions permitted work unusually late in the fall. There were many independent operators and prospectors mining on a small scale and the large companies were fully supplied with men.

Not only did the number of properties being worked increase during the year but there was also a notable increase in the number of dredges operating. The largest number of these were employed by the Société Industrie du Platine on its placers in the Verchotur district. That

these dredges are handling the ground in a satisfactory manner may be inferred from the last report of the company which states that the profit made in 1911 was 4,827,084 francs, and from the fact that the company has extended its operations on placers leased from the Demidoff estate and Prince San Donato. The capitalization of the company is 20,000,000 francs and it paid a dividend of 10 per cent. in 1911.

Three new companies were formed during the year for the exploitation of the Ural platinum placers on a considerable scale—the Aktai Platinum Company with placers on the Aktai river in the Verchotur district, the Sosva-Ural Company, and the Vogran Corporation.

PRODUCTION OF PLATINUM IN RUSSIA.

| Year. | Official. | Actual. | Year. | Official. | Actual. | Year. | Official. | Actual. |
|---|---|---|---|---|---|---|---|---|
| | oz. | oz. | | oz. | oz. | | oz. | oz. |
| 1895..... | 141,757 | 290,900 | 1901..... | 203,257 | 315,200 | 1907..... | 172,064 | 310,000 |
| 1896..... | 158,326 | 200,000 | 1902..... | 197,024 | 380,806 | 1908..... | 156,792 | 250,000 |
| 1897 ..... | 179,879 | 395,200 | 1903..... | 192,976 | 226,000 | 1909..... | 164,513 | 275,000 |
| 1898..... | 193,213 | 203,100 | 1904..... | 161,950 | 290,120 | 1910..... | 176,334 | 300,000 |
| 1899..... | 191,464 | 380,900 | 1905..... | 167,950 | 200,450 | 1911..... | 187,008 | 280,000 |
| 1900..... | 163,060 | 212,500 | 1906..... | 185,546 | 210,318 | 1912..... | 177,596 | 300,000 |

PRODUCTION OF PLATINUM IN THE URALS.
(In troy ounces.)

| District. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|
| South Verchotur..... | 97,747 | 100,986 | 111,070 | 121,317 | 118,281 |
| North Verchotur..... | 13,032 | 14,727 | 11,858 | 11,367 | 13,061 |
| Perm..... | 36,735 | 39,867 | 46,071 | 46,882 | 38,706 |
| Teherdinsk..... | 7,452 | 7,161 | 6,361 | (*a*)6,400 | 6,166 |
| South Ekaterinburg..... | 1,826 | 1,772 | 974 | (*b*)1,042 | (*c*)1,382 |
| Total..... | 156,792 | 164,513 | 176,334 | 187,008 | 177,596 |

(*a*) Estimated. (*b*) Includes 2 oz. from North Ekaterinburg.
(*c*) 5 oz. from North Ekaterinburg.

Notwithstanding the general activity in the platinum placers, the industry seems to be in a transition stage because of proposed legislation to prohibit the exportation of crude platinum. The final passage of such a law is, of course, being strongly opposed by the large French, German, and English interests who at present practically control the output of the Ural field either through contracts with the larger operators or through companies which they themselves operate. The Russian Duma, notwithstanding this opposition, accepted on June 4, a law including the following regulations of the platinum industry.

1. The prohibition of the exportation of crude platinum beginning at a date to be fixed by the Minister of Trade and Industry as soon as the entire domestic production may be refined in Russia, either in a refinery to be erected by the State or in private refineries, or both.

2. The delivery of special certificates to the purchaser of platinum by the managers or owners of placers indicating the place where the platinum was produced.

3. The obligation of each holder or purchaser of platinum to obtain such certificates.

4. The registration by holders of platinum of their dealings in it.

5. The establishment of penalties for non-observation of rules issued for the purpose of giving effect to these measures.

There are at present only three platinum refineries in Russia—the Zentclieff Chemical Works, at St. Petersburg; Kolbe & Lindfors, St. Petersburg; and the Outiakoff Works, at Ekaterinburg. These handle only about 2 per cent. of the entire domestic production. The establishment of a government refinery was proposed with the idea of its forming a link between the producers and foreign consumers, but no money was voted for its construction and the question was left open. The requirements of registration were adopted to prevent the sale of stolen platinum or metal on which the government tax had not been paid.

Another bill which came before the Duma proposed that all the platinum mined must be delivered to the Imperial Bank which would advance £3, 19s. for each troy ounce of 83 per cent. platinum so delivered, and that a special state committee fix in advance the quantity and prices of platinum to be exported annually. The question of direct loans by the Imperial Bank on platinum delivered to it was also considered as being of possible assistance to small producers in enabling them to outwait periods of low prices. The whole matter of platinum legislation is greatly involved, but the question of a state monopoly did not come before the Duma, and it may therefore be assumed that the matter is buried.

Although the Duma has issued rules for the sale, purchase, and holding of crude platinum, the time when these rules shall go into effect is to be fixed by the Minister of Trade and Industry acting with the Minister of Finance. Further, the rules must be submitted to the Imperial Senate for publication, and must then receive the Imperial sanction and be published again before they become law. In view of this enormous quantity of red tape there is a good chance that the whole matter may be sidetracked through pressure brought to bear by the larger operators and foreign refinery interests and never become a law at all. The small operators are well aware of this possibility, and in the fall they held a meeting at Ekaterinburg to consider ways and means of improving the chances of the final passage of legislation favorable to their interests.

During the year there were several discoveries of new platinum deposits, the most important of which was in the Irbit district near the village of Pokrovsky on the Bobrovka River. This deposit is south of

ose now being mined in the Urals and is considered as an extension of e productive region. There was also a discovery of platinum in the yanchai district, south of the governments of Yenissei and Irkutsk. the summer of 1911 some large nuggets of platinum were found in this trict and the many outcrops of olivine rock in the region indicate that ere is a possibility of its becoming an important producer of platinum.

In the accompanying table which shows the course of the platinum rket at Ekaterinburg and St. Petersburg in 1912, and also the course the market in New York, the Russian prices have been reduced to nerican weights and currency and are for crude metal—83 per cent. tinum. The New York prices are for refined metal. The smaller erators, prospectors, and tributors sell most of their output at Ekater-burg, while the large operators send their product directly to St. Peters-rg, which is the wholesale market.

AVERAGE PRICES OF PLATINUM IN 1912.
(In dollars per troy ounce.)

| | New York Refined Platinum. | Russia, Crude Metal—83 Per Cent. Platinum. | |
|---|---|---|---|
| | | St. Peters-burg. | Ekaterin-burg. |
| January | $46.00 | $37.73 | $37.50 |
| February | 45.63 | 37.83 | 37.60 |
| March | 45.50 | 37.63 | 37.47 |
| April | 45.50 | 37.29 | 37.10 |
| May | 45.50 | 37.00 | 37.04 |
| June | 45.50 | 36.80 | 36.85 |
| July | 45.50 | 36.75 | 36.85 |
| August | 45.50 | 36.75 | 36.85 |
| September | 45.50 | 36.75 | 36.85 |
| October | 45.50 | 36.75 | 36.85 |
| November | 45.50 | 36.80 | 36.85 |
| December | 45.50 | 36.95 | 36.85 |
| Average for 1912 | $45.55 | $37.08 | $37.05 |
| Average for 1911 | 43.12 | 35.21 | 35.09 |

At the beginning of the year the Russian market was rather inactive, alers being quite uncertain as to which way it would turn. Crude tal, 83 per cent. platinum, was quoted at Ekaterinburg at 10 roubles per lotnik—$37.60 per ounce, and at 38,500 roubles per pood—$37.73 per nce—at St. Petersburg for the same grade. There was a slight advance prices in February, after which they declined very gradually until ay 23 when quotations at Ekaterinburg were 9.80 roubles per zolotnik—ual to $36.85 per ounce, and at St. Petersburg, 37,500 roubles per pood, ual to $36.75 per ounce. Quotations practically remained at these ures for the remainder of the year which closed with a strong market d a specially good demand for small lots.

## Russian Platinum in 1912

By C. W. Purington

The officially reported platinum product during 1912, from statistics kindly furnished by the Secretary of the Gold and Platinum Miners' Bureau at St. Petersburg is as follows:

| District. | Poods. | Pounds. | Zolotniks. |
|---|---|---|---|
| North Ekaterinburg | ..... | ..... | 34 |
| South Ekaterinburg | 2 | 24 | 63 |
| Cherdinsk | 11 | 28 | 35 |
| Perm | 73 | 19 | 83 |
| North Verkotur | 24 | 32 | 2 |
| South Verkotur | 224 | 23 | 43 |
| Total | 337 | 8 | 68 |

In ounces of 83 per cent. raw platinum the product is:

| Troy Ounces. | Value at Present Price Per, Ounce. |
|---|---|
| 177,596 | $6,539,084.00 |

From the experience of former years, it may be confidently stated that the actual product was from 20 per cent. to 25 per cent. higher. The Ekaterinburg price for 83 per cent. platinum in January last was Rs. 9.70 per zolotnik, corresponding to $36.72 per Troy ounce.

At the same time the price in New York for refined platinum was $45 per troy ounce and for hard metal $47 per ounce (7.3 zol. = 1 oz.).

In Russian figures, the difference in price between the 83 per cent. product in Ekaterinburg and the refined product in New York is expressed at:

| Per Zolotnik. | Roubles. |
|---|---|
| Ekaterinburg raw | 9.70 |
| New York refined | 12.23 |
| New York hard metal | 12.49 |
| Per Troy Ounce. | |
| Ekaterinburg raw | $36.82 |
| New York refineff | $45.00 |
| New York hard metal | $47.00 |

Here is a difference of 18.2 per cent. between the prices which a buyer must pay for an ounce of 83 per cent. crude platinum in Ekaterinburg and an ounce of refined platinum in New York.

It is interesting to examine closely into the reason for this. It should be understood that the alluvial platinum as brought to the market by

the miners is mixed, in part mechanically, in part chemically, with impurities.

The 17 per cent. impurities in a given quantity of platinum dust are approximately as follows, on an average:

| | |
|---|---|
| Iridium | 5 per cent. |
| Gold | 2 per cent. |
| Lead, Iron, Copper | 10 per cent. |
| | 17 per cent. |

The ounce of Ekaterinburg mixture is worth at New York prices:

| | |
|---|---|
| Platinum (83 per cent.) | $37.35 @ $45 per ounce. |
| Iridium (5 per cent.) | 4.20 @ $84 per ounce. |
| Gold (2 per cent.) | 0.34 @ $17 per ounce. |
| | $41.89 |

The platinum producer on the Iss receives therefore for this product, which is worth $41.89, only $36.82 per troy ounce. This last price is 53 cents lower per ounce than the New York price for 83 per cent. pure platinum product. The total loss of the producer is then, per ounce:

| | |
|---|---|
| For difference in price of platinum | $0.53 |
| For iridium content | 4.20 |
| For gold content | 0.34 |
| | $5.07 |

Allowing 7 cents as the cost of transporting one ounce of platinum from Ekaterinburg to New York, it is apparent that if the platinum miners refined their own product in the Ural, they would receive instead of $36.82 per ounce for their 83 per cent. product, a figure of $41.82 per ounce. This is based on the New York quotation for January of this year. This price is 12 per cent. more than they receive at present. In other words, the platinum producers are under present conditions penalized at the rate of $5 per ounce for the 10 per cent. impurities contained in the product. This penalty theoretically is necessary to pay

(*a*) For the profit of the broker,

(*b*) For the cost of cleaning and refining.

It seems to be a price which is unnecessarily high. It should be realized by American consumers who take the largest percentage of the world's platinum output, that in addition to paying tribute to platinum miners, the failure to make direct purchases of platinum parcels at Ekaterinburg puts on them an entirely unnecessary burden.

Even under the present out-of-date and laborious placer methods in vogue in the Ural platinum fields, the production of an ounce of platinum does not cost over $30 at the outside. This is allowing a working cost of 75 cents per cubic yard for all material handled. It is beyond question that if the Iss and Tura fields were worked systematically by modern

plants, the cost of producing platinum could be reduced to one-half what it is at present, and even less. When the cost of working unfrozen easily dredgeable gravel exceeds 25 cents per cubic yard in any large and convenient field like the Iss, something is radically wrong.

It is worth while calling attention to the fact that with modern methods platinum mining in the Urals can be made an extremely profitable business. A perusal of my article in last year's volume of the MINERAL INDUSTRY will indicate that the river Iss, from which at least 70 per cent. of the world's platinum is derived is an ideal area for exploitation by modern dredges. Curiously enough, up to the present not one modern dredge of the heavy Californian type has been installed on it. This and other rivers in the North Ural will unquestionably be worked intensively by dredges in time to come, when the present feeble machinery used for this purpose in the Ural shall be replaced by properly designed equipment. Platinum is present in the following rivers beside the Iss, Tura, Veeya, and Aktai rivers, all of which taken together comprise the Tura river system.

The rivers of the Tagil estate, Utka, Visim, Martian and Shaitanka constitute the second field.

Next in importance comes the Sosva, north of the Bogoslovsk estate. It is estimated that 500,000 oz. of platinum are contained in the gravel of the Sosva, but how much of this is recoverable at a profit is uncertain. Some of it certainly is. At present there are two or three small and inefficient dredges operating on it. They do not clean the bed-rock, have very small capacity, and much of the platinum dredged up goes back into the pond through inefficient saving apparatus.

The Lozva, Lobva, Nyasma, Lyalya and Solda Rivers all contain more or less important stores of alluvial platinum, while in the far north Ural platiniferous gravel hitherto practically unexplored is known to exist.

The American consumer is in the ridiculous position of paying a heavy tribute to French miners, German buyers, and English brokers to obtain an article, the mining of which is free to all comers. Neither the Russian Government nor Russian private companies or individuals make anything to speak of out of the platinum business. Contrary to popular and seemingly ineradicable ideas there is *no export duty* on platinum imposed by the Government, and there are no French or other foreign platinum monopolies. Such monopoly as does exist can be said to be only a result of lack of attention on the part of those most interested in the consumption of this valuable metal.

Persistent rumors are current as to the introduction of legislation in the Duma imposing such export taxes on raw platinum as shall make its refining in Russia compulsory. It is very doubtful if such legislation

would benefit the small peasant producer, if such is its intention. If parental legislation is contemplated it would much better direct attention to improving the mining methods of not only the small but also the large platinum producers.

The present state of the platinum industry in fact affords the most striking illustration that in the mining of metals, Russia is in need not so much of foreign capital as of properly applied foreign and especially American technical assistance for developing to the fullest extent her unquestionably great resources.

# POTASSIUM SALTS

The consumption of potassium salts during 1912, like other fertilizers, showed a decrease. While no features in the potash trade changed the relations with the foreign source, the efforts made to find new sources in the United States were continued as energetically as in 1911. The reconciliation between the American buyers and the German producers in 1911 has been of a permanent nature. The following table shows the imports of potassium salts of various kinds for consumption for fiscal years:

IMPORTS OF POTASSIUM SALTS. (a)
(Tons of 2000 lb.)

| | 1908 | | 1909 | | 1910 | | 1911 | | 1912 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| Bicarbonate | 109 | $ 11,500 | 171 | $ 16,915 | 167 | $ 16,633 | 163 | 16,428 | 138 | $ 13,155 |
| Carbonate (crude) | 3,903 | 269,318 | 4,814 | 324,540 | 4,204 | 263,643 | 5,340 | 327,400 | 3,299 | 207,417 |
| Carbonate (refined) | 8,428 | 575,731 | 5,505 | 379,392 | 4,518 | 303,917 | 5,572 | 395,728 | 5,313 | 383,958 |
| Chloride | 118,475 | 3,885,419 | 148,669 | 4,758,907 | 195,927 | 5,640,541 | 214,283 | 6,449,575 | 242,033 | 7,235,728 |
| Chlorate | 7 | 1,052 | 10 | 1,655 | 207 | 26,608 | 12 | 2,096 | 21 | 3,444 |
| Chromate | 59 | 8,447 | 86 | 12,330 | 439 | 43,037 | 11 | 1,699 | 22 | 2,273 |
| Cyanide | 1,644 | 494,915 | 1,376 | 386,354 | 1,211 | 328,146 | 1,163 | 326,973 | 1,048 | 312,777 |
| Hydrate (crude) | 2,971 | 241,995 | 3,521 | 294,409 | 4,392 | 358,855 | 3,713 | 309,965 | 4,211 | 330,684 |
| Hydrate (refined) | 23 | 4,967 | 64 | 9,289 | 72 | 11,095 | 41 | 9,254 | 39 | 8,096 |
| Kainit | 329,467 | 2,008,555 | 344,526 | 1,974,165 | 484,155 | 2,313,150 | 656,842 | 2,637,103 | 479,817 | 2,400,590 |
| Nitrate (crude) | 8,374 | 517,334 | 8,735 | 512,473 | 12,573 | 675,765 | 4,645 | 282,835 | 3,086 | 213,258 |
| Nitrate (refined) | 163 | 17,487 | 208 | 14,421 | 1,306 | 115,457 | 426 | 38,384 | 221 | 23,896 |
| Prussiate (red) | 26 | 10,697 | 39 | 13,522 | 33 | 12,460 | 27 | 10,230 | 35 | 11,264 |
| Prussiate (yellow) | 410 | 88,637 | 877 | 178,744 | 1,165 | 229,907 | 889 | 180,584 | 1,036 | 203,295 |
| Sulphate | 28,276 | 1,030,470 | 30,508 | 1,148,607 | 42,485 | 1,399,915 | 53,135 | 1,952,371 | 50,551 | 1,853,236 |

(a) For the fiscal years ending June 30.

The world's principal source of potash, except from the nitrates of India at the present time, is the German Empire. The deposits were accidentally discovered in the course of operations for salt, and some of the hard potash and magnesian rock encountered was considered worthless for a long time. Several of the mines were owned and operated by different German States, the oldest and largest being in Prussia. In addition, some of the largest mines are owned and operated by the Grand Duchy of Anhalt, and others by the State of Brunswick, where the Sollstedt works are. A few mines also exist in Saxony. Stassfurt near the Harz has for centuries worked its salt mines. Wells were drilled by the government in 1839, and at first the bitter brines were considered worthless for salt. Rock salt mines discovered in other localities

finally caused these wells to be abandoned. Efforts were then made by the government to reach the salt beds from which these brines came. In 1857 at a depth of 1080 ft. after penetrating a large deposit of magnesia salts, the salt proper was encountered, but at this date the deposit of potash penetrated was considered worthless. To-day the average cost of producing a metric ton of kainite at Stassfurt is about $1.72; per ton of potassium chloride, $14.84; per ton of sulphate of potash, $21.38; and per ton of manure salt, $10.08.

The following table shows the production of potassium salts in Germany in recent years as officially stated:

PRODUCTION OF POTASSIUM SALTS IN GERMANY. (*a*)
(In metric tons and dollars; 1 mark = $0.238.)

| Year. | Kainit. | | Potassium Salts other than Kainit. | | Potassium Chloride. | | Potassium Sulphate. | | Potassium Magnesium Sulphate. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| | | $ | | $ | | $ | | $ | | $ |
| 898 | 1,103,643 | 3,835,856 | 1,105,212 | 3,576,628 | 191,347 | 6,380,220 | 18,853 | 763,397 | 13,982 | 259,485 |
| 899 | 1,108,159 | 3,838,250 | 1,384,972 | 4,202,000 | 207,506 | 6,801,250 | 26,103 | 1,027,500 | 9,765 | 195,000 |
| 900 | 1,178,527 | 4,134,000 | 1,874,346 | 5,643,750 | 271,512 | 8,793,750 | 33,853 | 1,249,250 | 15,368 | 280,500 |
| 901 | 1,500,748 | 4,327,250 | 2,036,326 | 5,443,250 | 282,750 | 8,782,250 | 27,304 | 1,460,000 | 15,612 | 286,500 |
| 902 | 1,322,633 | 4,571,980 | 1,962,384 | 4,949,448 | 267,512 | 7,507,710 | 28,279 | 1,079,092 | 18,147 | 334,390 |
| 903 | 1,557,243 | 5,208,154 | 2,073,720 | 4,993,478 | 280,248 | 8,125,320 | 36,674 | 1,389,444 | 23,631 | 441,252 |
| 904 | 1,905,893 | 6,322,470 | 2,179,471 | 5,305,972 | 279,238 | 8,425,676 | 43,959 | 1,664,572 | 29,285 | 545,972 |
| 905 | 2,387,643 | 7,976,808 | 2,655,845 | 6,396,250 | 373,177 | 10,580,528 | 47,994 | 1,804,040 | 34,222 | 614,754 |
| 906 | 2,720,594 | 8,918,574 | 2,821,073 | 6,538,336 | 403,387 | 11,034,632 | 54,490 | 2,032,520 | 35,211 | 644,028 |
| 907 | 2,624,412 | 8,579,206 | 3,124,955 | 7,314,930 | 473,138 | 12,639,704 | 60,292 | 2,216,494 | 33,368 | 631,652 |
| 908 | 2,715,487 | 9,196,082 | 3,383,535 | 7,720,006 | 511,258 | 13,369,174 | 55,756 | 2,037,518 | 33,149 | 663,068 |
| 909 | 3,181,349 | 10,646,792 | 3,860,685 | 8,787,198 | 624,994 | 16,245,642 | 68,539 | 2,574,684 | 38,722 | 697,816 |
| 910 | 4,249,667 | 12,712,056 | 4,062,004 | 9,034,004 | 741,259 | 17,371,144 | 84,583 | 2,989,756 | 37,439 | 668,066 |
| 911 | 4,425,497 | 13,757,452 | 5,181,379 | 11,794,328 | 838,420 | 19,851,342 | 107,631 | 3,967,460 | 42,253 | 780,974 |

(*a*) From *Vierteljahrshefte zur Statistik des Deutschen Reichs.*

Comparing the exports from Germany, these were officially stated in 1911 as 392,129 metric tons of potassium and magnesium sulphate, and 1,154,974 tons of Stassfurt salts (kainit, kieserite, etc.). The following table gives the production of fertilizer salts of potassium mined in 1911 and 1912:[1]

| | 1911. | 1912. |
|---|---|---|
| | *Tons.* | *Tons.* |
| Nitrate of potash (80 per cent. $K_2O$) | 443,357 | 471,435 |
| Sulphate of potassium (90 per cent. $K_2O$) | 110,123 | 115,728 |
| Sulphate of potassium magnesium (48 per cent. $K_2O$) | 49,014 | 55,987 |
| (40 per cent. $K_2O$) | 144 | 173 |
| Manure salts of at least (38 per cent. $K_2O$) | 38,620 | 48,059 |
| (20 per cent. $K_2O$) | 169,812 | 174,867 |
| (30 per cent. $K_2O$) | 57,502 | 64,514 |
| (40 per cent. $K_2O$) | 379,790 | 483,877 |
| Kainite and sylvinite | 3,212,632 | 3,251,003 |
| Carnallite and mined kieserite | 80,660 | 70,462 |

[1] The American Fertilizer Hand-book for 1913.

The exports during the last 3 years are given in the following table:[1]

| | 1910. | 1911. | 1912. |
|---|---|---|---|
| Kainit, Kieserit, etc | 1,181,208 | 1,154,974 | 1,300,559 |
| Potassium, muriate | 270,227 | 329,734 | 286,528 |
| Potassium sulphate | 76,285 | 109,555 | 85,452 |
| Pot. mag. sulphate | 197,408 | 282,574 | 48,540 |

The exports metric tons to the United States are given in the following table:[2]

| | 1911. | | 1912. | |
|---|---|---|---|---|
| | Total. | To U. S. | Total. | To U. S. |
| Muriate of potash | 329,751 | 229,241 | 286,528 | 190,775 |
| Sulphate of potassium | 109,529 | 56,893 | 85,452 | 35,366 |
| Sulphate of potassium magnesium | 282,574(a) | 143,775 | 48,540 | 14,172 |
| Carnallite with at least 9 per cent. and less than 12 per cent. $K_2O$ | (b) | ..... | 6,853 | ..... |
| Raw potash salts with from 12–15 per cent. $K_2O$ | ..... | ..... | 852,984 | 461,279 |
| Raw potash salts with more than 15 per cent. and less than 20 per cent. $K_2O$ | ..... | ..... | 35,529 | 29,533 |
| M nure salts, including potash salts with 38 per cent. $K_2O$ | ..... | ..... | 373,665 | 149,907 |
| Abraum salts, Stassfurter salts, etc | ..... | ..... | 31,222 | 9,578 |

(a) Including manure salts.
(b) The total sum of the exports of the last five salts (carnallite to abraum salts inclusive) for the year 1911 was 1,167,972 metric tons, and for the year 1912, 1,300,253 metric tons.

The original mine owners combined for maintaining level prices by apportioning the total output, so that the poorest was insured a profit. The Prussian government supervised this Kali Syndikat; the Imperial Government did not exercise control originally but favored a policy of government operation. In 1880 the German Potash Syndicate included some other works besides those of Prussia. In 1905 the Sollstedt Works entered into contract with United States buyers and declined to join the syndicate. The United States buyers are the large fertilizer corporations, namely the American Agricultural Chemical Company and the Virginia-Carolina Chemical Company; a group of independents including Armour & Co., and Swift & Company, and others making fertilizers as a secondary product; and a very large group of jobbers, cotton-seed oil manufacturers, including about a dozen chemical manufacturers. These three groups are the importers in the United States.

The independents were not satisfied with the reduction in prices made to other American buyers, and contracts were made with the Sollstedt Works for a longer period and by some of the purchasers that had already

[1] The American Fertilizer Hand-book for 1913.
[2] American Fertilizer Hand-book for 1913.

contracted with the syndicate. Prices were not fixed, being subject to the current ones paid by the two large fertilizer manufacturers. The cutting of prices, with the prospect of destruction of the potash industry in Germany, resulted in the passing of the Prussian mining law of 1907, the State exercising the sole right to mine and explore minerals. In 1907 also the Sollstedt Works joined the syndicate, but on handing over its contracts with the independents the difference in price charged by the syndicate to other consumers enabled the independents to buy at a lower price than the syndicate contract. The syndicate expired in the middle of 1909 and American importers arranged for large individual supplies. The Govėrnment, however, threatened its legislation, causing the temporary renewal by all the producers excepting the Sollstedt, the Aschersleben and the Einigkeit Works. The Reichstag, on May 10, 1910, passed its potash law, regulating the distribution up to 1925. The law prescribes the prices for different salts both domestic and for export, up to the end of 1913.

The following is a distribution authorized for 1913: It is not unlike the distribution in tons for 1912, the proportion being nearly the same, the total amounts being greater.

| | For German Consumption 100 kilos. of pure potash ($K_2O$). | For Export 100 kilos. of pure potash ($K_2O$). |
|---|---|---|
| Carnallite with 9 to 12 per cent. $K_2O$ | 72,100 | 700 |
| Crude potash salts with 12 to 15 per cent. $K_2O$ | 3,088,100 | 1,350,200 |
| Manure salts with 20 to 22 per cent. $K_2O$ | 22,300 | 346,100 |
| Manure salts with 30 to 32 per cent. $K_2O$ | 34,000 | 175,800 |
| Manure salts with 40 to 42 per cent. $K_2O$, including potash manure with 38 per cent. $K_2O$ | 1,658,300 | 605,500 |
| Chloride of potassium | 662,000 | 1,841,000 |
| Potassium sulphate | 17,000 | 574,500 |
| Potassium magnesium sulphate | 1,900 | 151,200 |
| Totals | 5,555,700 | 5,042,000 |

The potash law only restricts production or consumption for the quantity that may be exported. Each mine owner is bound to contribute the whole of his portion of the domestic consumption and not more than his portion of the foreign consumption. If the total for both domestic and foreign has been underestimated, it is changed in the course of the year. At the beginning of the year the first estimates exceed those of the preceeding year by at least 5 per cent. The contracts made by the Sollstedt and Aschersleben Works were judged to have been made in violation of the syndicate rules, and 300,000 marks each were collected from these works by the syndicate for breach of contract. Subsequent contracts made were always for larger quantities than the quota, had the producers been members of the syndicate. For example, the alloted quota of the

Sollstedt Works in 1910 was 1.64 per cent., and that of the Aschersleben was 2.23 per cent. After the potash law went into effect, the Aschersleben Works and the Sollstedt Works refused to make any further contracts except upon the buyer paying the penalty. This the buyers refused to do in many cases. The only buyers of potash in the United States who were affected by this law, therefore, were those who agreed to pay any Governmental charge. No complaint was made by the independents nor by the Virginia-Carolina Chemical Company having contracts with the Sollstedt Works. The appeal to the American Government was mostly on the part of those middle men or independents holding contracts which required them to pay the penalty levied by the syndicate. It was claimed by these independents that the legislation was discriminating against the United States. There is no duty on potash salts imported as fertilizers and had the government taken the view that the measure was discriminatory, it could have threatened to impose a maximum import duty. The matter was finally adjusted without the government's aid and many supplemental contracts were made at reduced figures, but the buyers assuming the risk. As it was impossible to monopolize the exports to the United States, the Sollstedt and Aschersleben Works re-entered the syndicate in 1911, and matters were adjusted, the price basis for new contracts being practically the same as that prevailing before the enactment of the law. The basis of contract settlements varies with the quantity. The price schedule of the syndicate for 1912 and 1913 is as follows:[1]

BAG SALT.

(In bags of 200 lb. net weight. No charge for bags.)

| | |
|---|---|
| Muriate of potash, 80 to 85 per cent., basis 80 per cent. | $38.05 per ton (2000 lb.) |
| Muriate of potash, min. 95 per cent., basis 80 per cent. | 39.65 per ton (2000 lb.) |
| Muriate of potash, min. 98 per cent., basis 80 per cent. | 40.50 per ton (2000 lb.) |
| Sulphate of potash, 90 to 95 per cent., basis 90 per cent. | 46.30 per ton (2000 lb.) |
| Sulphate of potash, min. 96 per cent., basis 90 per cent. | 46.85 per ton (2000 lb.) |
| Double manure salt, 48 to 53 per cent., basis 48 per cent. | 24.45 per ton (2000 lb.) |

BULK SALT

| | |
|---|---|
| Manure salt, min. 20 per cent. actual potash | $13.30 per ton (2000 lb.) |
| Hardsalt, min. 16 per cent., actual potash | 10.65 per ton (2000 lb.) |
| Kainit, min. 12.4 per cent. actual potash | 8.25 per ton (2000 lb.) |

The effect of the legislation in Germany did not act in the desired action of keeping the potash industry in a healthy condition. Especially are new producers dissatisfied, inasmuch as they must enter the pool with a very small quota. In 1912 about 80,000,000 marks have been invested in the new potash enterprises in Germany, and in addition to 115 works now in the syndicate, 162 more will be ready to produce in a few years. A retroactive law may be passed modifying the present in a number of points. The members of the syndicate at present require new members to wait for their full quota, 5 years. This time is to be extended to 10 years, the idea being to deter new enterprises. The

[1] American Fertilizer Hand-book.

present dues used for a general public fund amount to 60 pfennige per hundred kilograms of $K_2O$, and this is to be doubled. Also the State is benefited by two-thirds of the dues, one-third only being applied for the benefit of the industry.

The sales of potash salts in 1912 amounted to $42,142,857 against $38,819,047 in 1911.

*Potash in other Foreign Countries.*—In Belgium the potassium compounds in the wool grease industry and also from the residues from beet-sugar manufacture, compete with the foreign potash market. The factories engaged in evaporating wash water, etc., for this purpose, produce annually about 1100 tons of crude potassium carbonate. At seven distilleries in Belgium, the liquid residue from the stills is evaporated and calcined, giving a crude product containing 40 to 70 per cent. potassium salts. An average of this product is 10 per cent. by weight of the molasses employed. The total annual product is 4000 tons. Three refineries are engaged in making a 95 per cent. product from the crude.

One factory at Antwerp still produces solid caustic potash to the extent of 500 tons per year, but as electrolytic potash is imported freely from Germany, it is becoming unremunerative. In 1911 Belgium purchased 7800 tons of caustic potash.

In Iceland the existence of basalt from which phonolith can be extracted is attracting attention. It is intended to erect a works capable of turning out 900 tons of phonolith a week, and this will employ about 200 men. The experiments thus far, however, are based only on samples taken near Hafnofjord in the Reykjavik district. An Austrian syndicate is to operate potash salts in Galicia. Part of the potash fields belong to the Government of the province. Galician potash is not exported, being mined only for local use.

In India the Loanr Lake deposits are described by T. H. D. La Touche.[1] Crude soda has been obtained from the Lake for centuries. The analyses are approximately as follows:[2] The salts are produced in the order named, papri being the first crystals collected:

| | Papri. | Dulla. | Khuppal. | Dulla Nimak. | Nimak Dulla. |
|---|---|---|---|---|---|
| Soda ($Na_2O$)..... | 33.36 | 33.65 | 35.17 | 34.42 | 44.54 |
| Potash ($K_2O$)..... | 10.29 | 7.14 | 6.88 | 9.95 | 4.28 |

An extensive leucit-phonolite deposit in Central Italy is to be worked by a syndicate of Berlin mining men. The German geologists think favorably of this deposit for extracting potash for fertilizing purposes.

[1] Rec. Geol. Surv., Ind., 1912, 41, Part IV.
[2] F. J. Plymen, *Ind. Trade Journ.*, 1909, 14, 229

The material runs from 16 to 20 per cent. potassium. The deposit lies near the coast. The Mexican Government has granted a concession for the seaweeds along the coast of Lower California. The exportations must commence before the middle of 1913.

The utilization of kelp as a source of iodine and potash salts in Norway continues to be a prominent industry on the shores. As in Scotland, Normandy, and Japan, this industry is able to compete with Chili iodine. There are nine establishments along the Norwegian coast, able to supply the home demand, and to export about $53,000 worth of iodine, and 2318 metric tons of ash, valued at $64,000 per year. These nine works furnish potash fertilizers, though the industry is not as well perfected as in Scotland. The product called "Norgine" is made directly from the kelp and is a new mucilaginous substance used in finishing textiles.

In Russia in the North Caucasus, the industry for burning the sunflower stalks for potash carbonate yielded a product from which 6282 tons of potash were exported in 1911. Of this, 195 tons valued at $43,744 went to the United States. The imports of kainite, potash salts, etc., into Russia, are enumerated in the article on "Phosphate."

*Production of Potash in the United States.*—The possibilities of a potash production in the United States are very promising. Notably the brines, from Searles Lake, California, offer the opportunity for a process that will extract potassium chloride, sulphate of soda, salt and borax.

The commercial possibilities are supplemented by researches of the U. S. Geol. Surv. enumerated below. Land withdrawals and proposed laws are to provide a definite basis for development of deposits now known and such as may be discovered.

The President recently approved the withdrawal of three tracts of land, aggregating 133,829 acres, of the desert-basin type in California and Nevada. The first of these withdrawals covered Columbus Marsh, Nevada, and was approved on Jan. 16, 1913. The second included the famous Searles Lake, California, and was approved on Feb. 21, 1913. The third included lands in the Panamint Valley, California, the acreage affected being 24,567 acres. The withdrawals are not destructive of any valid claims that may now exist. The bed of Searles Lake is blanketed with filings, the majority of which have been made under the general placer law providing that 160 acres may be entered as an association placer, but there is danger that the legality of these filings may be destroyed by agreements, made prior to patent, to combine a group of placers after patent is received, in order to obtain an area large enough to serve as a basis for a plant for extracting and refining the salts.

Over 200 desert basins have been studied by the Bureau of Soils in

reference to their being a possible potash source. Considering the conditions under which potash would predominate in residual brines, concentrated from former large bodies of water and drainage areas most of the saline crusts, dry lake areas, salt flats, etc., in the desert regions offer little promise of commercial potash. Potassium bearing brines derived from massive beds of crystalline salts offer greater promise, provided the methods of separation can be perfected. These require elaborate processes and technical skill.

The deposits of rock salt east of the Rocky Mountains are not promising as a source of potash; potash salts are included in minute quantities only during the crystallization of the sodium chloride.[1]

The Silver Peak Marsh, Nevada, as a result of borings and analyses, is not a possible producer of potash. Salt is estimated, however, at 15,000,000 tons within 40 ft. of the surface. No borax is reported.

Columbus Marsh, Nevada, comprises about 35 square miles. Solid core samples were taken from 8 holes up to 38 ft. in depth; the core containing from 6 to 17 per cent. of soluble salts, which analyzed from 3 to 40 per cent. KCl. The average contents of the soluble portion, 6 per cent. of a 20 ft. depth, would appear to be 30 per cent. KCl. The saline solutions from the wells are too dilute to be of commercial importance.

Railroad Valley, Nev., has been prospected by a company which also drilled in Dixie Valley and elsewhere. The search was for submerged deposits. One hole reached a depth of 1200 ft. The crusts and brines from Railroad Valley analyze from 2 to 11 or 12 per cent. $K_2O$ in the solids which range up to three-fourths of the total sample; analyses of 168 samples are given in *Journ. Ind. Chem.*, Vol. V, Jan., 1913, p. 22.

The results at Fallon, Nevada, showed that no potash salts are disseminated in the sediments of sand, etc. These form the bottom of the old Lake Lahontan, which is supposed never to have overflowed and the drilling was done at one of the lowest points in the basin. Possibilities have not been exhausted, however, and drilling is to continue at other points.

Searles Lake, Cal., may be reached by stage from Johannesburg via Searles. The lake also known as Borax flat is a dry basin. The analyses of six brine samples from old wells at considerable depth showed uniform results and an average of 6.78 per cent. of the dissolved salts are potash. The brine saturated salt body is at least 60 ft. thick and covers an area of 11 square miles. If the brine is taken at 25 per cent. by volume, the contents estimated is 6,000,000 tons of KCl. One part was originally, 30 years ago, worked by John W. Searles for borax at Borax Camp. In 1898

[1] J. W. Turrentine, *Eighth Int'l. Cong. Appl. Chem.*

the possibilities for potash were suggested by Whitman Symmes, a mining engineer of California and Nevada.

The deposit was later worked for soda by C. E. Dolbear who relocated the area.

The calculated average of salts in the anhydrous residue of the brine is as follows:

| | |
|---|---|
| $NaCl$ | 51.61 per cent. |
| $Na_2SO_4$ | 19.22 per cent. |
| $Na_2CO_3$ | 12.79 per cent. |
| $Na_2B_4O_7$ | 3.23 per cent. |
| $KCl$ | 12.07 per cent. |
| $Na_3AsO_4$ | 0.17 per cent. |
| | 99.09 per cent. |

The original brine contains bicarbonate, here calculated as carbonate.

M. Dolbear gives the following data of interest:[1]

The smooth hard salt floor extending over an area of 12 square miles was examined by boring in 1911, by Smith Emery & Co., of San Francisco. An average of analyses with depths is as follows:

SAMPLE BORINGS IN SEARLES LAKE.

| Depth (feet). | Insol. | NaCl. | $Na_2SO_4$. | $Na_2CO_3$ | $NaHCO_3$. | $Na_2B_4O_7$. | $H_2O$. |
|---|---|---|---|---|---|---|---|
| 0–18 | 0.2 | 79.7 | 7.6 | 3.2 | 0.0 | tr. | 3.3 |
| 18–25 | 1.4 | 44.0 | 30.5 | 14.8 | 2.5 | 1.0 | 5.8 |
| 25–30 | 1.4 | 47.3 | 28.1 | 10.6 | 0.0 | 2.0 | 10.6 |
| 30–35 | 3.0 | 42.7 | 17.1 | 19.1 | 5.9 | 2.0 | 10.2 |
| 35–50 | 1.4 | 43.5 | 22.3 | 9.5 | 2.5 | 5.5 | 15.3 |
| 50–65 | tr. | 82.8 | 10.6 | 3.2 | 0.8 | tr. | 2.6 |
| 56–79 | tr. | 19.0 | 7.3 | 40.3 | 18.5 | 0.5 | 14.4 |

No potassium salts were reported because they are included as sodium chloride, the presence of potassium in large quantities not being suspected until later. Borings outside the salt bed area showed larger quantities of carbonates and an unusual amount of borax between 30 and 45 ft. depths. All of the deposit is coarsely crystalline, much honey combed, the interstices filled with a brine containing all of the salts of the deposit except sodium bicarbonate, which is nearly insoluble in the solution. The brine has a specific gravity of 1.3. Below 23 ft. depth the brine contains 16.77 per cent. NaCl, 5.46 per cent. $Na_2SO_4$, 4.61 per cent. $Na_2CO_3$, 1.32 per cent. the $Na_2B_4O_7$, 4.49 per cent. KCl; total 32.65 per cent. The calcined product is as follows: 51.3 per cent. NaCl, 16.7 per cent. $Na_2SO_4$, 14.1 per cent. $Na_2CO_3$, 4 per cent. $Na_2B_4O_7$, 13.8 per cent. KCl. This brine is 18 per cent. of the total weight of the deposit.

The brine carrying the more valuable salts occurs below the sodium-chloride bed. The underlying bed averages approximately 47 ft. thick. The area of the bed explored is 12 square miles. The total weight of

[1] *Eng. and Min. Journ.*, Vol. XCV, Feb., 1913, p. 259.

the underlying bed is approximately 800,000,000 tons, and 18 per cent. of this is 144,000,000, tons.

As the brine carries an average of 4.49 per cent. potassium chloride the tonnage of that salt in solution is then 4.49 per cent. of 144,000,000 or 6,465,600 tons. The brine also carries 1,900,000 tons of anhydrous borax, equivalent to 3,400,000 tons of commercial borax. Also the brine carries 6,630,000 tons of sodium carbonate.

The solids of the deposits below the sodium-chloride bed have the following average analysis: Insoluble (sand etc.), 1.44 per cent.; sodium chloride, 45.90; sodium sulphate (anhydrous), 22.80; sodium carbonate (anhydrous), 16.57; sodium bicarbonate, 6.50; sodium biborate (anhydrous), 2.32; potassium chloride, 3.64 per cent.

The total amounts of the valuable salts in solid form are then: Sodium carbonate, 108,500,000 tons; sodium bicarbonate, 42,700,000 tons; sodium biborate (anhydrous), 15,200,000 tons = 27,300,000 tons of commercial borax; potassium chloride, 23,900,000 tons.

The salines of the desert basins contain chlorides largely, but little or no magnesium. This salt is present in the evaporation of a normal sea, like the Stassfurt deposits.

Samples from Death Valley, California, have not given encouraging results. The best of the natural brines found, a surface ground water, gave only 1.53 per cent. KCl, while the average of 15 brines tested was only 0.94 per cent. KCl, which is about the average content of most natural desert brines. The mode of deposition probably is not favorable to selective crystallization on a large scale.

Saline Valley, Inyo Co., Cal., salt contains 0.37 potassium sulphate. Carrizo Plain, San. Louis Obispo Co., Cal., brines contain very small amounts of potash associated with the sodium sulphate deposits.

Other possible sources for potash were examined as follows: A well 305 ft. deep in Permian Beds at Adamana, Arizona; the black alkali at Cochise Flat, Arizona; Fourmile flat, Nevada; alkali ponds and muds in various counties in Nebraska; Estancia Valley, N. M.; Crater Salt Lake, N. M. The potash is present in small quantities in all of them, but the dilution makes extraction commercially impossible.

An occurrence of almost pure potassium nitrate is found in the northern part of the Granite range, Nevada T 37 N., R. 22 E. The nearest railroad station is Gerlach.

The nitre deposits near Melrose, Mont., are described by R. W. Richards.[1] The composition of the purest soluble material is: CaO 4.63 per cent., $SO_3$ 8.19, Cl 8.61, $N_2O_5$ 40.05, $Na_2O$ 16.72, and $K_2O$ 22.05 per cent. The average soluble portion of the samples is from 1 to 5 per

[1] *Bull. 540, U. S. Geol. Surv.*, 1913.

cent., hence 35 tons of rock would yield 1 ton of crude salt. If refined this would yield 440 lb. sodium nitrate and 790 lb. potassium nitrate, valued respectively at $24 and $41 per ton; or $1.80 per ton of original rock.

The deposits of nitrate 6 miles east of Queen, N. M., are not of commercial importance. The rock covering the efflorescence contains 1.16 per cent. $KNO_3$.

The utilization of bitterns remaining from the grainer process in Eastern States and those obtained from the crystallizing salt ponds along the Pacific coast has not been attempted, although the potash content is of sufficient percentage, if the quantity were large enough. Such analyses are the following:

| | K. | Na. |
|---|---|---|
| Watkins Salt Co., Watkins, N. Y. | 3.8 per cent. | 34 per cent. |
| International Salt Co., Watkins, N. Y. | 3.9 per cent. | 35 per cent. |
| Mulkey Salt Co., Detroit, Mich. | 3.9 per cent. | 30 per cent. |

Other analyses show a smaller per cent. of K.

*Alunite.*—Deposits of alunite occur in the following places: Marysville[1], Utah; basin at the head of Middle Piedra River, Colo.; head of South River, east of Piedra Peak, Colo.; Carson, Colo.; Slumgullion Gulch, Colo.; southwest of Lake City,[2] Colo.; Patagonia,[3] Ariz., and Bovard, Nevada. The deposit 5 miles south of Patagonia, Ariz., occurs in altered granite porphyry at the 3R copper mines, Palmetto mining district. Pyrite and chalcopyrite are present, and also some apatite and zircon. The deposit is not shown to have commercial value. The Bovard deposit occurs in the tabular sheets in fissures of Tertiary volcanics and Paleozoic limestone at the Gold Pen mine and the Valley View prospect. The mineral has a large proportion of sodium and is called natroalunite.

*Leucite.*—The rocks of the Leucite Hills, Sweetwater County, Wyoming,[4] are of volcanic origin, and consist of fine-grained, rather earthy-looking lavas, composed chiefly of a mixture of mica, diopside, and leucite, with a variable amount of orthoclase (potash feldspar). With the exception of diopside, all these minerals contain a considerable quantity of potash, the amount in leucite being about 21.5 per cent., that in the orthoclase 16.9 per cent., and that in the mica 10.7 per cent. The greater part of the potash present, however, is represented by the two

[1] *Bull.* 511, *U. S. Geol. Surv.*, 1912.
[2] E. S. Larsen, Alunite in the San Christobal quadrangle, Col., *Bull.* 530, *U. S. Geol. Surv.*, pp. 179-183.
[3] F. C. Schrader, *Bull.* 540, *I. U. S. Geol. Surv.*, to be issued 1913.
[4] A.R. Schultz and W. Cross, *Bull.* 512, *U. S. Geol. Surv.*, 1912.

nerals leucite and mica. Some of the rocks contain as much as 26 per nt. of leucite. The chemical analysis of samples of the leucite-bearing cks shows that the potash ($K_2O$) varies in amount from 7.99 per cent. 11.91 per cent., the average of nine analyses giving 10.74 per cent. king 10 per cent. of potash as a moderate average for the leucite-aring rocks, it is estimated that the Leucite Hills of Wyoming contain t less than about 197,000,000 tons of potash.

The problem of manufacturing potash from the silicate rock is being rked on more energetically than ever. Feldspar and leucite are the o prevalent minerals containing potash.

In a paper before Eighth International Congress Applied Chemistry, berton S. Cushman and Geo. W. Coggeshall go into details of the proc-es classed as follows:

Natural agencies, such as those kaolinizing feldspar.
Wet treatment as with alkaline solutions, hydrofluoric acid, etc.
Chemical dry processes in which potash salts are volatilized after heating with fluxes.
Dry processes separating the potassium as chloride.
Dry processes producing sulphates.

The conclusion is reached that the dry processes without actual fusion the reacting mixture are most feasible. The Cushman process (U. S. tent 987436, March 21, 1911), together with the Coggeshall process of paring the material (U. S. patent 987554), are most promising. A ge scale test has been made on eleven carloads of feldspar containing m 6 to 11 per cent. $K_2O$ and 3 per cent. $Na_2O$. A quicklime (90 cent. CaO, 5.6 per cent. MgO) was powdered and used in the following portions: feldspar 100, CaO 20, NaCl 10 or 20. A thin layer of the xture was moistened with a 42 per cent. solution of $CaCl_2$, obtained m the Solvay Process Company in the solid form and containing 75 cent. $CaCl_2$+25 per cent. $H_2O$. By supplying the solution through all nozzles, clumps of the oxychloride cement are formed of about 1/2-diameter; these are screened and heated in a cement kiln fired with wdered coal. The product is ground and contains free lime and potas-m chloride, and in this form it is being tried on the crops.

Methods of aggregating feldspar ground to different mesh showed the thod adopted in the continuous process with 100-mesh feldspar to ld within 3 per cent. of the total potash in soluble form. During heat-in the kiln from 1 to 2 per cent. $Na_2O$ is volatilized. When operating h no salt, 47.5 per cent. of the potash is converted into chloride. With per cent. salt (feldspar 100 per cent.), 64 per cent. is KCl, but 9 per nt. is volatilized. With 20 per cent. salt the KCl becomes 75 per cent.

and 7 per cent. is volatilized. When the feldspar contains 10 per cent. $K_2O$ and 2 per cent. $Na_2O$, the 100, 20, 20, 20 mixture gave clumps analyzing as follows:

| | | |
|---|---|---|
| Total $K_2O$ | 5.8 | |
| Water soluble $K_2O$ | 4.2 | (6.65 KCl) |
| Loss $K_2O$ | 0.5 | (=as KCl already formed) |
| Total $Na_2O$ | 7.1 | (52 per cent. into NaCl) |
| Water soluble $Na_2O$ | 5.1 | (26 per cent. of the NaCl vaporized) |
| Total CaO | 15.5 | |
| Free lime | 11.2 | |
| $CaCl_2$ | 5.0 | |

The mixture with only 10 parts of salt gave clumps as follows:

| | | |
|---|---|---|
| Total $K_2O$ | 5.62 | |
| Water soluble $K_2O$ | 4.5 | (=7.12 KCl) |
| Loss $K_2O$ | 1.04 | |
| Insoluble $K_2O$ | 1.12 | |
| Total $Na_2O$ | 4.15 | |
| Water soluble | 3.7 | (11 per cent. of the NaCl vaporized) |
| Free CaO | 12.25 | |

The net yield of $K_2O$ is 57.6 per cent. soluble in the product. Some of the insoluble potash is citric acid soluble. In practice this process may be improved to yield much better results, but the product now actually obtainable is equal in fertilizing value to that of hard wood ashes.

Analyses of potash bearing minerals are compiled by Wm. H. Ross, Bureau of Soils:[1]

TABLE I.—ANALYSES OF POTASH-BEARING MINERALS.

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| $SiO_2$ | 0.22 | 51.56 | 65.87 | 44.39 | 50.23 |
| $TiO_2$ | ..... | ..... | ..... | ..... | 2.27 |
| $Al_2O_3$ | 37.18 | 6.62 | 19.10 | 35.70 | 11.22 |
| $Fe_2O_3$ | Trace | 15.16 | ..... | 1.09 | 3.34 |
| FeO | ..... | 8.33 | ..... | 1.07 | 1.84 |
| MgO | ..... | 0.95 | None | ..... | 7.09 |
| CaO | ..... | 0.62 | 0.20 | 0.10 | 5.99 |
| $Na_2O$ | 0.33 | 1.84 | 2.56 | 2.41 | 1.37 |
| $K_2O$ | 10.46 | 4.15 | 12.24 | 9.77 | 9.81 |
| $H_2O$ | 12.99 | 10.32 | 0.64 | 5.88 | 2.65 |
| $P_2O_5$ | 0.58 | ..... | ..... | ..... | 1.89 |
| $SO_3$ | 38.34 | ..... | ..... | ..... | 0.74 |
| Fl | ..... | ..... | ..... | 0.42 | 0.50 |
| Other constituents | ..... | ..... | ..... | ..... | 1.68 |
| | 100.10 | 99.55 | 100.61 | 100.83 | 100.62 |

[1] Alunite from Marysvale, Utah. Selected Specimen. Analysis by W. T. Schaller, *Bull. U. S. Geol. Surv.*, No. 511, p. 8.

[2] Glauconite from greensand marl. Hanover Co., Virginia. Analysis by M. B. Corse and C. Baskerville, *Am. Chem. Journ.*, 14,627.

[3] Ground commercial feldspar from quarry of J. B. Richardson & Sons, Bedford, Ont. Analysis by George Steiger, *Bull. U. S. Geol. Surv.*, No. 420, p. 9.

286.

[4] Muscovite from Auburn, Maine. Analysis by R. B. Riggs, *Bull. U. S. Geol. Surv.*, No. 419 p. 286.

[5] Leucite-bearing rock, Wyoming. Analysis by W. F. Hillebrand, *Bull. U. S. Geol. Surv.*, No. 512. p. 11.

*Potassium Hydroxide.*—A large part of the crude caustic used in the United States comes from the Canadian lumber camp wood ashes and

[1] *Eighth Int'l. Cong. Appl'd. Chem.*

contains, say, 65 per cent. potash, the balance soda. As stated by H. D. Rhum, vice president, Niagara Alkali Co., before the Ways and Means committee Jan. 6, 1913, this material was intended to enter free of duty. In recent years the electrolytic process for making caustic gives directly a product of 90 to 95 per cent. potash; this being imported in drums from Germany evades the duty of 1 cent per pound. In the past 4 years the wholesale price has been reduced by the importers from $180 per ton to $80, an effort being made to drive the American manufacture out of business, which would allow the restoring of a higher price. The raw material for one of the original electrolytic processes for making potash is the mineral from Stassfurt, Prussia, controlled by the Kali syndicate. Although able to produce a good quality of potash the American producers were not able to compete when the price of the imported article was cut at the end of 1909 to $102.50, in 1910 to $95; in 1911 to $90 and in 1912 to $80 per ton. The large consumers are the soap and woolen trades which take 95 per cent. of the product. The American caustic-soda producers are also able to produce potash. Bleaching powder is a by-product of the potash manufacture.

The plant of the Niagara Alkali Company has been enlarged and will represent an investment of $800,000 exclusive of process patents purchased in Germany.

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# PRECIOUS STONES

By George F. Kunz

During 1912 a rather remarkable condition existed in the precious stone market. Pearls continued to advance; diamonds advanced, and there was an unprecedented demand for sapphires. Emeralds were at their former price and rubies had become so rare that they were sought and appreciated, but the newer favorites were more in demand.

Quantities of diamonds weighing from 1/64 to 1/300 of a carat, the latter single-cut brilliants of many facets, were used to a large extent in successive or minute ribbon-work and in ways that diamonds have never been used before, the labor on the material representing frequently three-fourths or more of the cost of the stones themselves.

Sapphire has been unusually favored since January, 1912. These stones have materially advanced in price, and never have finer sapphires been sold than since this demand set in. Many of the stones are cut *en cabochon*, the finest in Cashmere and Burma. This special favor has increased the demand for Montana sapphires, which, although they usually run anywhere from a carat down to 1/16 of a carat, rarely weighing as much as two carats, possess the property of retaining their color by artificial light. They have been unusually popular, being mounted in many ways that are at once attractive and often inexpensive. The Balkan War has suggested to Dame Fashion the demand for various colored stones. In a variety of colored combinations, the stones are being caliber-cut, that is, square and fitted into a setting without any intervening gold between them, and such combinations as tourmaline, red and green or blue sapphires, green tourmaline, yellow topaz, purple amethyst, and many other color combinations have been made up. These caliber-cut or mitred stones have also been cut in three-stone shapes to form circles, ellipsoids, and other quaint forms.

The precious stone cutters' art and that of the diamond cutters have never before been taxed to so great an extent as at present, nor has there ever been such a demand for the many forms of cutting. Many gems have been cut double-briolet, pear-shaped, and in other curious forms that take a pendant shape, and others have been cut with a grooved edge at the girdle along which the setting is slipped so as to be almost invisible. During the past year some remarkable pockets have been found contain-

ing red tourmaline (rubellite) on Pala Mountain, San Diego Co., California, as well as an enormous deposit of kunzite, the lilac spodumene at the same locality. Some of the crystals of rubellite weighed as much as 11 lb., and there were kunzites of from a few ounces to 4 lb. Occasionally the crystals had been shattered by blasting, but could be repaired for employment as cabinet specimens.

The finest of these have found their way, by gift, to the American Museum of Natural History, the Musée d'Histoire Naturelle, in Paris, and to the Holden Collection which was willed to Harvard University.[1] During the further development of the Humboldt County opal deposits there has been brought to light a great variety of replacement of prehistoric wood by opal of the greatest variety of colors, petroleum brown with a most intense and vivid flash of red, green and blue fire, and often with a faint purple reflection, and most magnificent and absolutely colorless pellucid opals, as well as those with magnificent colors in flame, red and green. These have been cut into beads. Some of the blacker material with the intense red, green and blue fire, resemble that from New South Wales. A new gem variety of golden beryl from German Southwest Africa is named heliodore.

The proposal to impose a duty of 20 per cent. on all cut stones imported into the United States has naturally met with strenuous opposition on the part of the gem-dealers. This opposition is dictated not only by business interests, but also by the great probability that under a duty of 20 per cent., instead of the former rate of 10 per cent., an immense amount of smuggling would be induced, thus placing reputable gem importers at a decided disadvantage.

A careful study of the figures for the imports of diamonds, precious stones and pearls into the United States for the period from 1867 to the present time shows that while the value of these imports has increased from decade to decade, this increase has not been constant and steady from year to year. The year 1879 marked the end of a period of general depression; with the year 1880 began an era of prosperity and of generally increasing values. 1893 was a high-water mark for the time being; the wave of prosperity had spent its force, and there ensued a rapid falling off in precious stone imports. In 1896 the tide turned again, and with the exception of the year 1900, when a presidential election exerted a disturbing influence, the increase was most remarkable. In 1907 came our recent financial panic and nothing can more strikingly illustrate the absolute dependence of the gem-market upon financial prosperity than the rapid decline of precious stone imports to $31,866,599 in 1907 and

[1]The collection of the late Albert F. Holden of Cleveland was the finest private collection of minerals in the United States, and was bequeathed to Harvard to be combined with existing collections.

to but $13,700,404 in 1908. But the recuperative powers of our land are so astonishing that this period of depression has been immediately followed by 4 years in each of which the gem imports have run over $42,000,000; the last 3 years are remarkable in the nearly identical figures, showing a steady demand.

IMPORTS OF PRECIOUS STONES.
Nine quinquennial periods, 1868–1912.

| | Imports. | Annual Average. |
|---|---|---|
| 1868–72 | $10,224,033 | $2,044,806 |
| 1873–77 | 13,836,574 | 2,767,314 |
| 1878–82 | 31,435,735 | 6,287,147 |
| 1883–87 | 42,400,515 | 8,480,103 |
| 1888–92 | 62,869,792 | 12,573,958 |
| 1893–97 | 35,094,294 | 7,018,859 |
| 1898–1902 | 88,501,998 | 17,700,399 |
| 1903–07 | 168,482,604 | 33,696,520 |
| 1908–12 | 184,202,674 | 36,840,534 |

Four decennial periods, 1873–1912.

| | Imports. | Annual Average. |
|---|---|---|
| 1873–82 | $45,272,309 | $4,527,230 |
| 1883–92 | 105,270,307 | 10,527,030 |
| 1893–1902 | 123,596,292 | 12,359,629 |
| 1903–12 | 352,685,278 | 35,268,278 |

IMPORTS OF PRECIOUS STONES FOR THE YEARS 1909, 1910, 1911, 1912.

| | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|
| Diamonds, uncut, including miners', glaziers', and engravers', not set. Free | $ 8,789,649 | $ 9,204,134 | $ 9,854,152 | $ 9,863,770 |
| Diamonds, cut, but not set. Dut | 27,369,405 | 25,672,639 | 25,705,563 | 22,876,042 |
| Pearls and parts of, not strung or set. Dut | ..... | 464,712 | 1,387,689 | 5,139,406 |
| Other precious stones, uncut. Free | 440,638 | 222,513 | 109,241 | 115,812 |
| Other precious and semi-precious stones, cut, but not set. Dut | 6,970,864 | 6,751,832 | 4,519,263 | 3,342,219 |
| Imitation precious stones. Dut | ..... | ..... | 587,256 | 1,215,471 |
| Total precious stones, etc., | $43,570,556 | $42,315,830 | $42,163,164 | $42,552,720 |

IMPORTS OF PRECIOUS STONES AND PEARLS INTO THE UNITED STATES FROM 1867 TO 1908

| | |
|---|---|
| Diamonds; glaziers', miners', and engravers', not set | $ 3,277,209 |
| Diamond dust | 6,787,740 |
| Diamonds, rough or uncut | 83,994,001 |
| Diamonds, set | 53,969 |
| Diamonds, cut, but not set | 152,784,223 |
| Diamonds and other stones, not set | 211,556,278 |
| Pearls | 20,120,798 |
| | $478,574,218 |
| Grand total, 1867 to 1912 inclusive | $649,176,488 |

In the first 9 months of the present fiscal year, which ends June 30, 1913, official figures show that precious stones worth $35,000,000 were imported into the United States, while the totals for the same period in

each of the 2 preceding years were about $30,000,000. The corresponding returns for 1900 were worth but $11,000,000. This indicates the rapidly growing wealth of the nation, and also the increasing tendency to satisfy the merely aesthetic cravings of the purchaser. While it is true that in the case of precious stones the greater part of the immediate returns go abroad, this, in turn, augments the purchasing power of foreign lands and so in the endless chain of commercial distribution is to the advantage of all.

## DIAMONDS

The unsettled political conditions in Europe due to the Balkan troubles did not stimulate the demand for diamonds. The strong demand for small diamonds has operated greatly to the advantage of mines such as the Premier and especially to that of the diamond mining enterprises in German Southwest Africa; in both fields an unusual proportion of the diamonds secured is quite small. Indeed, the diamond industry seems to be in a very favorable state both here and abroad.

The diamond interests of 1912–1913 have been influenced latterly by the threatened advance in the customs duties from 10 to 15, and even 20 per cent., with the result that many importers bought large quantities of diamonds, importing them so as to relieve themselves of a large part of the duty they might have to pay later on. This excess buying has strengthened the precious stone market abroad.

The exports of diamonds to the United States from the two ports of Amsterdam and Antwerp for the period 1905–1912 inclusive, compare as follows:

| Year. | Amsterdam. | Antwerp. |
|---|---|---|
| 1905 | $10,425,814 | $ 6,465,464 |
| 1906 | 12,435,161 | 6,448,894 |
| 1907 | 7,905,852 | 6,283,576 |
| 1908 | 4,571,804 | 4,408,366 |
| 1909 | 12,441,243 | 12,914,793 |
| 1910 | 10,655,753 | 10,857,038 |
| 1911 | 10,080,851 | 11,357,475 |
| 1912 | 10,645,280 | 10,903,894 |
| | $79,161,758 | $69,639,500 |

The cut diamonds amounted to $10,009,324 in 1911 and $9,665,027 in 1912; the rough diamonds $1,348,151 in 1911 and $1,238,867 in 1912.

According to the consular invoices the value of the diamonds sent from Antwerp to New York, given in quarterly periods, was as follows:

| Cut Diamonds. | 1911. | 1912. |
|---|---|---|
| First quarter | $3,331,201 | $ 2,230,324 |
| Second quarter | 2,701,961 | 2,433,942 |
| Third quarter | 2,491,503 | 2,589,355 |
| Fourth quarter | 1,484,659 | 2,411,406 |
| | $10,009,324 | $ 9,665,027 |
| Rough Diamonds. | | |
| First quarter | $ 222,296 | $ 331,994 |
| Second quarter | 317,713 | 210,099 |
| Third quarter | 540,734 | 381,101 |
| Fourth quarter | 267,408 | 335,673 |
| | $ 1,348,151 | $ 1,238,867 |
| Grand total | $11,357,475 | $10,903,894 |

*Diamond Cutting Industry.*—Through the extensive use of the saw in cleaving diamonds, and also because of the competition of independent workers, the wages of the Dutch diamond cleavers have declined somewhat during 1912. Efforts are being made by the union to arrive at some understanding with the independent workers, so that a certain concert of action may be attained, tending to a stiffening of wages. There is said to be good prospect of success. The union's finances seem to be in good condition to judge from the fact that it has been decided to assign an allowance to all who have been out of work for 2 weeks, instead of for 6 weeks, as was formerly the rule.

The founding of diamond-cutting schools in Hanau and in Berlin has been announced for the near future by the German Colonial Secretary, Dr. Solf, in a communication to the Reichstag. In these proposed schools instruction is to be imparted in the Amsterdam system of diamond-cutting. While the task of transplanting in whole or part any well-established industry is a very difficult one, the supply of rough diamonds from Africa is large enough.

This will, if successful, make a marked difference in the industry in Antwerp, for of last year's German diamond production 94.55 per cent. went to Antwerp, but 4.79 per cent. being Germany's share, and it is believed that barely 3 per cent. was actually cut in Germany. One-third of the small amount of the diamond material brought to Germany was exported in a rough state.

An effort may be made to establish a diamond-cutting industry in South Africa, and to facilitate this the majority of a senatorial committee has recommended that an export tax of from 5 to 10 per cent. be levied on all rough diamonds taken out of South Africa. Skilled labor is to be introduced from abroad for the development of a school of cutting.

A conservative minority would place the duty at but 2 per cent., while still another minority report altogether opposes the proposition.

It is possible that the threat to start the diamond-cutting industry at the Cape may only be a ruse to effect a compromise on the general question of imposing an export duty on diamonds.

*United States.*—While but little development work was done in the Arkansas diamond field in 1912, there is reason to believe that the current year will show better results.[1] The Osark Company, the owner of some 5 or 6 acres of the first large pipe discovered, has already installed a steam washing, crushing and recovery plant, which can treat a hundred loads of ground daily. As this is the first application of practical methods to diamond mining in this region, the operation of this plant is expected to show more definitely than has heretofore been possible the character and quality of the diamond deposits. Another washing plant is in process of erection on Prairie Creek, on the neighboring tract leased from Mr. Mauny. The other interests in this field have not been so active. The largest owner, the Arkansas Diamond Co., did but little work; however, the small amount of washing performed always revealed the presence of diamonds in the ground. Many test pits were sunk during the year, and at one spot a diamond-drill hole was bored to a considerable depth to test the weathering quality of the peridotite. Little or no work was done either by the Kimberley Co. or by the American Diamond Mining Co. The ground to be mined by this latter company lies a few miles to the north of the large pipe.[2]

A small diamond crystal has been found in black sands from the Rock Flat Placer Mine, in township 19, range 2, east B. M., Idaho. These black sands appear to have their source in a dike of a blue basaltic clay, about 200 ft. wide, which seems to traverse at right angles the rock formation of a hard schistose granite, or gneiss, interspersed with quartzite dikes. On an average the blue clay carries gold to the value of $2.87 per ton. The composition of the black sands, supposed to be derived from it, is as follows:

| | |
|---|---|
| Magnetite | 629.4 lb. per ton |
| Chromite | 564.1 lb. per ton |
| Monazite | 123.8 lb. per ton |
| Zircon | 329.5 lb. per ton |
| Quartz | 232.5 lb. per ton |

A ton of black sands also carries about $10 worth of gold and platinum. In this mining field have also been found some fine rubies and sapphires.[3]

[1] For full details of these diamond deposits see "Diamonds in Arkansas," by George F. Kunz and Henry S. Washington, *Trans.* A. I. M. E., (New York Meeting), pp. 187–194; John T. Fuller in THE MINERAL INDUSTRY for 1908, pp. 734–738; and also the writer's reports on precious stones in THE MINERAL INDUSTRY for 1910, pp. 578, 579, and for 1911, p. 634.

[2] John T. Fuller, "Diamond Mining in Arkansas," in *Eng. and Min. Journ.*, January 11, 1913.

[3] Communication of Mr. Frank E. Johnesse, of Boise, Idaho.

*Africa.*—A recently reported estimate of the aggregate value of the mineral products of South Africa up to the present date gives the following stupendous figures for the gold and diamond production.[1]

[1] Report of Minister of Finance of the Union of South Africa.

| | | |
|---|---|---|
| Gold | £363,000,000 | $1,815,000,000 |
| Diamonds | 170,000,000 | 850,000,000 |
| Coal | 25,000,000 | 125,000,000 |
| Copper | 9,500,000 | 47,500,000 |
| Tin | 1,750,000 | 8,750,000 |
| | £569,250,000 | $2,846,250,000 |

At present the diamond interests in South Africa appear to be fairly well adjusted, so that, without any hard and fast agreement, those in control of the leading companies can avoid any risk of injurious competition. The German Diamond Regie, while acting independently, has established itself so firmly as regards the market for the smaller diamonds, that from this direction also no ill-considered or improvident management of the diamond situation need be apprehended. A close bond unites the interests of the De Beers and Premier companies through the large holdings of shares in both companies by Barnato Bros. It appears, however, as though the special relations of the Transvaal State with the Premier Co. would preclude any formal amalgamation of it with the De Beers Co.; indeed, this is quite unessential for the attainment of united action. The New Jagersfontein mine in the Orange Free State is practically part of the same complex of interests.

That the control of a smaller company by a larger one does not always help to raise the value of the smaller company's shares has been shown in the case of the Koffyfontein mines, the controlling interest in which has recently passed into the hands of the group controlling the De Beers Co., with the result that the price of the shares has fallen from $15 to $10. A like result is shown in the shares of the Voorspoed Company, which have gone down in selling value from $12.50 to $5 since the De Beers interests have acquired control. The reason for this is, of course, the risk that production may be diminished or checked in the small mine in case market conditions make this course seem advisable to those managing the larger concern.

The total production of diamonds in the Union of South Africa for the first 6 months of 1912 is officially reported to have been 2,392,255 carats, valued at the equivalent of $22,100,970. This shows a decrease from the previous half year amounting to 651,192 carats. However, the value was only reduced $30,940, owing to the advance in diamond prices.[1]

[1] Consul Edwin N. Gunsaulus of Johannesburg, *Daily Consular and Trade Reports*, 26, 1912.

TOTAL PRODUCTION OF DIAMONDS IN UNION OF SOUTH AFRICA FOR 1911.[1]

| | Mines. | | Alluvial. | | Total. | |
|---|---|---|---|---|---|---|
| | Carats. | Value. | Carats. | Value. | Carats. | Value. |
| Pretoria (Premier) | 1,802,093 | £1,426,891 | 2,155 | £1,909 | 1,804,248 | £1,428,800 |
| Pietersburg | ..... | ..... | 951 | 3,474 | 951 | 3,474 |
| Klerksdorp | ..... | ..... | 38,142 | 196,607 | 38,142 | 196,602 |
| Transvaal | 1,802,093 | £1,426,891 | 41,248 | £201,985 | 1,843,341 | £1,628,876 |
| Kimberley (De Beers) | 2,158,315 | £4,967,360 | 8,629 | £52,026 | 2,166,944 | £5,019,386 |
| Barkly West | 296 | 1,076 | 78,365 | 465,094 | 78,661 | 466,170 |
| Herbert | ..... | ..... | 2,002 | 9,981 | 2,002 | 9,981 |
| Kuruman | ..... | ..... | 2,898 | 10,875 | 2,898 | 10,875 |
| Cape | 2,158,611 | £4,968,436 | 91,894 | 537,976 | 2,250,505 | £5,506,412 |
| Boshof | 90,902 | £93,553 | 508 | £2,674 | 91,410 | £96,227 |
| Fauresmith, N. Jagersfontein, Koffyfontein | 462,367 | 1,302,418 | 3 | 4 | 462,370 | 1,302,422 |
| Kronstad (Voorpoed) | 242,112 | 210,541 | 33 | 61 | 242,145 | 210,602 |
| Winburg | 2,222 | 2,135 | ..... | ..... | 2,222 | 2,135 |
| Other places | ..... | ..... | 5 | 50 | 5 | 50 |
| Orange Free State | 797,603 | £1,608,647 | 549 | £2,789 | 798,152 | £1,611,436 |
| Union of South Africa | 4,758,307 | £8,003,974 | 133,691 | £742,750 | 4,891,998 | £8,746,724 |

De Beers.—The year ending June 30, 1912, was a prosperous one for the De Beers Co. The amount received from the sale of diamonds, after deducting decrease of stocks at production cost, was £5,630,968 8s. 3d. Taking from this £2,692,335 1s. 3d. for operating expenses and depreciation, £236,098 7s. 7d. for interest and sinking fund, and £358,155 8s. 7d. for taxes, there remained an available balance of £2,344,379 10s. 10d. as a result of the year's operations. From this were paid dividends of £800,000 on preference shares and £1,000,000 on deferred shares, as well as a bonus of £125,000 on the latter, leaving £419,379 10s. 10d., which added to the £623,019 15s. 11d. brought forward from 1911 made £1,042,399 6s. 9d. to be carried over to the current year. The net amount realized for diamonds sold was £692,882 in excess of that for the previous year.

The sum of £100,000 was added to the special reserve fund, making this £1,437,953. A special sinking fund has been created to provide for the payment of the 4 1/2 per cent. De Beers South African Exploration Debentures, due June 30, 1930, the year's contribution to this fund being £65,115. The Blue Ground Reserve valued at £2,268,266, of which £1,508,802 is on the floors, remains intact.

The sale of the Voorspoed Mine (Orange Free State) to the De Beers Company is believed to have been fully justified by the actual operating conditions there. During the past year £79,782 was realized by the sale of diamonds, but expenses so far exceeded this sum as to make a net loss

[1] From Mines Department Annual Report, Union of South Africa, for the calendar year ended December 31, 1911, Pretoria, 1912, Table 13.

of £41,278 on the operation. The progressive falling off in the average yield was continued, from 0.1612 carat per load in 1910 to 0.141 carat in 1911, and finally to 0.12897 carat in the first 7 months of 1912. As the diamonds sold at 19s. 11.35d. per carat, equal to 2s. 6.85d. per load at the last mentioned yield, while the cost of production was 3s. 2.2d. per load, increased production under the same conditions only added to the loss. The task of securing the large additional capital needed to enlarge and improve the plant to an extent that would promise better returns appeared to be a hopeless one, so that an acceptance of the cash offer of £253,571 made by the De Beers Company seemed to be the best, and indeed the only practical solution of the difficulty.

In addition to the nominal value of the shares amounting to £120,000 ($600,000) the stock holders received 4 1/2 per cent. debentures to the amount of 12s. 6d. per share.

The death of Sir Julius Wernher on May 21, 1912, marked the passing away of the last of the little group of Life Governors of the De Beers Company, the others having been Barney Barnato, Cecil Rhodes and Alfred Beit. His judgment and experience enabled him to render valuable service in the conduct of the company's affairs up to the closing years of his life. Although these men no longer live, the eminently successful organization they called into being testifies to their remarkable foresight and to their thorough business methods. Sir Julius was born in Darmstadt, Germany, and was the son of General Wernher. He entered commercial life in London, emigrating to South Africa when the importance of the gold and diamond discoveries was just beginning to be understood. The noted firm of Wernher, Beit & Co. was founded in Kimberley, and in its activities the part actually assigned to Sir Julius was that of seller, his enterprising yet withal cautious management proving eminently successful. This trait of caution was perhaps somewhat unduly manifested in the arrangements made with the notorious diamond-faker, Lemoinne, which are said to have entailed a loss of £64,000, yet had this man's claim been proven true—and there seemed to be good evidence in favor of this—the money would have been well expended. As it was, the De Beers shares rose 5s. when the fraud was finally exposed.

A comparison of the figures for July 1, 1911, and for June 30, 1912, would indicate a slight falling off in the number of white employees in the De Beers Mines, and a considerable decrease in the number of native laborers, although of course only average figures can be conclusive in this connection. Thus we have at the respective dates a decrease in white employees (men and lads) from 2786 to 2575 and in the number of native laborers from 17,654 to 14,712.

With the exception of No. 1 main rock shaft in the Dutoitspan Mine,

the depth of which was increased from 860 ft. to 1000 ft., the depths of the shafts remained as they were in 1911, being as follows:

| | |
|---|---|
| De Beers, Main rock shaft | 2466 ft. |
| No. 1 shaft | 1670 ft. |
| Kimberley, Main rock shaft | 3601 ft. |
| Atkins shaft | 1009 ft. |
| Wesselton, No. 1 Main rock shaft | 1119 ft. |
| No. 2 Main rock shaft | 988 ft. |
| Bultfontein, No. 1 Main rock shaft | 708 ft. |
| No. 2 Main rock shaft | 1084 ft. |
| Dutoitspan, No. 1 Main rock shaft | 1000 ft. |
| No. 2 Main rock shaft | 768 ft. |

THE OUTPUT OF THE DE BEERS CONSOLIDATED MINES, LTD.[1]

| Mine. | Loads Hauled. | Loads Washed. | Yield per Ld. Carat. | Value per Carat. | Value per Load. | Cost of Production. | Profit per Load. | Carats of Diamonds Found. |
|---|---|---|---|---|---|---|---|---|
| 1912 | | | | | | | | |
| De Beers } Kimberley } | 323,621 | 378,614 | 0.31 | 53s 11.47d | 16s 8.716d | 13s 6.78d | 3s 1.936d | 119,013 |
| Wesselton | 2,573,398 | 2,020,291 | 0.29 | 45s 3.12d | 13s 1.504d | 4s 7.576d | 8s 5.928d | 581,973½ |
| Bultfontein | 2,334,720 | 2,025,450 | 0.41 | 40s 8.242d | 16s 8.179d | 3s 11.357d | 12s 8.822d | 834,760½ |
| Dutoitspan | 2,718,703 | 1,845,796 | 0.23 | 83s 0.132d | 19s 1.11d | 3s 10.665d | 15s 2.445d | 428,213½ |
| | 7,950,442 | 6,270,151 | | | | | | |
| 1911 | | | | | | | | |
| De Beers } Kimberley } | 445,169 | 1,230,491 | 0.28 | 51s 6.29d | 14s 5.12d | 8s 7.67d | 5s 9.35d | 350,662½ |
| Wesselton | 2,422,487 | 1,423,117 | 0.27 | 37s 9.6d | 10s 2.47d | 4s 9.09d | 5s 5.38d | 390,192½ |
| Bultfontein | 2,457,412 | 1,866,212 | 0.38 | 35s 0.52d | 13s 3.79d | 3s 11.45d | 9s 4.34d | 700,398½ |
| Dutoitspan | 2,780,070 | 2,335,240 | 0.21 | 73s 6.5d | 15s 5.325d | 4s 7.09d | 10s 10.235d | 482,971½ |
| | 8,105,138 | 6,855,060 | | | | | | |

It will be noted that (excepting De Beers and Kimberley where the production was comparatively small) there was a considerable increase of profit per load, greatest in the case of Dutoitspan as in the previous year. This was principally due to the increased value of diamonds, although in Wesselton the cost of production was slightly, and in Dutoitspan considerably, less than in 1911.

The increased cost of production in the Kimberley Mine was due to the fact that the bulk of the material, coming from below the 2520-ft. level, had to be double-handled until hoisting apparatus was installed to work from the 3520-ft. level, the necessary equipment for this service also entailing a temporary increase in the production cost.

The following estimate has been made of the amount of blue ground in sight in the various mines above certain given levels.

| Mine. | Loads of Blue Ground. |
|---|---|
| De Beers, above 2040 ft. level | 2,750,000 |
| Kimberley, above 3520 ft. level | 2,200,000 |
| Wesselton, above 980 ft. level | 20,500,000 |
| Bultfontein, above 1000 ft. level | 13,000,000 |
| Dutoitspan, above 750 ft. level | 16,000,000 |
| | 54,450,000 |

[1] From Twenty-fourth Annual Report of the De Beers Consolidated Mines, Ltd., for the year ending June 30, 1912.

On the basis of profits secured during the past year, and averaging the results from the different mines, this blue ground would realize eventual profits of about £30,000,000 for the shareholders of the De Beers Company.

A proof that the yield in diamonds of diamantiferous ground does not necessarily diminish with the increase of depth whence the ground is taken is clearly demonstrated by a careful test made in the Kimberley mine. This mine has been carried down deeper than any other in South Africa and yet 2375 loads of blue ground from the 3500-ft. level gave an average yield of 0.42 carat per load, or 42 carats per 100 loads. From a piece of "hard blue" taken at this great depth was extracted a single diamond of good quality, estimated to be worth about £100. The significance of these figures becomes apparent when we consider that since 1905 the average carat yield of all the material taken from various depths in this mine, most of it of course from very considerably lesser depths than the maximum one of 3500 feet, has ranged from 0.28 carat to 0.42 carat (this latter average in 1909 alone) per load.

A decision rendered by the English Privy Council gave judgment in favor of the De Beers Company in the action brought against the Rhodesian Chartered Company. As a result all diamonds discovered in Rhodesia can be claimed by the De Beers Company.[1]

Premier.—The Premier mine continued to be the only important producer of diamonds in the Transvaal.[2] This company does not publish details of its production month by month, but the figures for 1912 have been estimated from the best information obtainable.

PREMIER (TRANSVAAL) DIAMOND MINING CO. LTD.

| Year Ended Oct. 31. | No. of Loads Washed. | Number of Carats Found. | Value of Diamonds. | Yield per Load in Carats. | Value per Carat. | Value per Load. | Cost of Production per Load. | Profit per Load. |
|---|---|---|---|---|---|---|---|---|
| | | | £ | | s. d. | s. d. | s. d. | s. d. |
| 1903 | 76,931 | 99,208 | 137,435 | 1.29 | 27 : 8.5 | 35 : 6.7 | 4 : 7.2 | ..... |
| 1904 | 939,265 | 749,653 | 866,030 | 0.798 | 23 : 1.2 | 18 : 5.3 | 2 : 7.62 | ..... |
| 1905 | 1,388,071 | 845,652 | 994,687 | 0.609 | 23 : 6.3 | 14 : 4.0 | 3 : 3.4 | ..... |
| 1906 | 2,988,471 | 899,746 | 1,277,739 | 0.301 | 28 : 4.8 | 8 : 6.6 | 3 : 5.7 | ..... |
| 1907 | 6,538,669 | 1,889,986 | 1,702,631 | 0.290 | 18 : 0 | 5 : 2.5 | 2 : 4.0 | ..... |
| 1908 | 8,058,844 | 2,078,825 | 1,536,720 | 0.258 | 14 : 9.4 | 3 : 9.75 | 1 : 10.2 | ..... |
| 1909 | 7,517,793 | 1,872,136 | 1,172,378 | 0.249 | 12 : 6.3 | 3 : 1.4 | 1 : 11.4 | 1 : 2.0 |
| 1910 | 9,331,882 | 1,245,832 | 1,496,641 | 0.230 | 13 : 11.4 | 3 : 2.5 | 2 : 0.5 | 1 : 1.9 |
| 1911 | 8,325,272 | 1,774,206 | 1,433,970 | 0.213 | 16 : 2 | 3 : 5.3 | 2 : 2.60 | 1 : 3.3 |
| 1912[1] | ..... | 2,006,000 | 1,810,000 | 0.205 | 18 : 0 | 4 : 1.6 | 2 : 4.8 | 1 : 8.8 |

[1] Estimated and partly for fiscal year.

The report of the Premier Mine for the year ending October 31, 1912, registers a banner year in the number of loads of blue ground hauled and washed, the total being 9,437,673 loads, besides 269,425 loads of tailings,

[1] *Eng. and Min. Journ.*, Feb. 17, 1912.
[2] H. F. Marriott, *Eng. and Min. Journ.*, Jan. 11, 1913.

making in all 9,707,098 loads. On a single day, September 23, 1912, 46,780 loads were taken out of the mine; and in each of the three months, July, August and September, 1912, the total exceeded 1,000,000 loads. This immense output considerably exceeded that of the De Beers group of mines, but the total number of carats of diamonds produced (1,992,474 carats as against 1,963,960 carats) was about the same, owing to the progressive falling off in the carat-average per load. Nevertheless the average value per carat has risen so steadily during the past few years that the profit per load, in spite of an upward trend in the cost of production, has also increased.

The diamond account for the year is credited with £2,004,943 3s. 5d. and net profits of £749,196 19s. 3d. were carried over to the Expenditure and Revenue Account. After deducting £76,612 for general equipment and 60 per cent. (£403,550) from the remainder as the share belonging to the Union of South Africa, the sum of £269,033 represented the realized profits for the year to be credited to the shareholders' account. Sundry revenue (£83,612) and the previous balance (£87,471) increased this to £440,118, enabling the company to declare two dividends of £50,000 on the preferred shares, and two dividends of £120,000 on the deferred shares, in all £340,000, and carry over a balance of £100,118 to the next year.

During 1912 difficulty was experienced in securing an adequate number of native workers in the diamond mines. It was found that the effort to supply workers from the Province of Cape Colony was not destined to be successful, as these natives were quite unsuitable. However, actual recruiting in other parts of the country, coupled with the inducement provided by the increased wage, supplied the deficiency that for a time existed in the labor market. Of the total number of natives admitted to the compound of the Premier Mine, 5359 came voluntarily, 18,255 being forwarded by agents, making in all 23,614. The daily average employed was 13,363, and the daily average wage 2s. 11.29d. There were 803 white employees.

This company inaugurated on November 1, 1912, a Pension Fund for its employees, four-fifths of the amount of the pension to be contributed by the company and one-fifth by the employees themselves. On this account the company made last year an initial appropriation of £85,000, the equivalent of the company's contribution to the fund had it existed from the date on which each employee entered its service. Should there be no change in the number of employees, the regular annual appropriation for this purpose will be about £10,000.

Another record find is reported from the Premier Mine, which can now place to its credit the two largest diamond crystals ever discovered.

The new diamond was uncovered by a blast near the bottom of the mine. The crystal is of a truncated egg-shape and weighs 1649 carats. Although it is stated to show a few black streaks, these are believed to be only superficial. The Cullinan crystal, also from the Premier, weighed 3025 3/4 carats, nearly twice as much, but the new diamond far exceeds in weight its nearest rival, the Excelsior, of 969 1/2 carats, from the Jagersfontein Mine.

The withdrawal of Mr. A. Wagner from the directorate of the Premier Company marks an epoch in its history, the removal of an influence that has contributed most potently to making this mine a great success. In his address at the last meeting, in yielding to the inevitable and recognizing the rights acquired by Barnato Bros. in the management of the company, he felt justified in using the following words: "I have the satisfaction to know that I have converted the strongest opponent the company ever had into the largest shareholder of to-day, which proves to me that he endorses our policy."

*Vaal River.*—The New Vaal River Diamond and Exploration Company of Barkly West, although its output for the year only totals 16,660 carats, realized for the diamonds the sum of £124,770, showing the unusually high average of £7 10s per carat. This is said to be due to the working of some exceptionally rich areas at Droogveld.

The Vaal River alluvial diggings in the neighborhood of Boshoff continue to prove more or less profitable to the many diggers at work there, according to their greater or lesser degree of luck in finding good-sized stones. The recent finding of a diamond crystal weighing 30 carats and worth £800 is reported from this field.[1]

The opening up of a deposit of true kimberlite, containing diamonds, ilmenite and garnets, is reported at Droogspruit, near Machavie, in the Potchefstroom district, where several shafts have been sunk to a depth of 70 ft.[2]

*German Southwest Africa.*—The diamantiferous region, title to which was acquired by the German merchant Lüderitz from the native chiefs, became, in 1885, the property of the Deutsche Kolonialgesellschaft für Südwestafrika. In 1908, when the first diamonds were found here, the greater part of the land owned by this company was legally open to all. To keep down the number of small proprietors whose mining methods were unlikely to result in the fullest, best, and most profitable working of the diamond deposits, the German Secretary of State for the Colonies decreed that the tract bounded on the north by 26° S. Lat., on the south by the Orange River, on the west by the ocean and on the east by a line

[1] *Eng. and Min. Journ.*, Dec., 1912.
[2] *South African Min. Journ.*, Oct. 26, 1912.

100 km. inland running parallel with the ocean, be reserved by the company for its own exclusive use; a considerable tract within this zone was assumed by the Government under previous agreements. However, a large number of claims had already been allowed, and the territory north of 26° was still left open, and it is stated that as many as four thousand small claims have been allowed.[1]

The output of diamonds in German Southwest Africa is increasing.[2] The supply from this source is now over 100,000 carats per month. This is in spite of conditions such as a scarcity of labor and a rather oppressive customs system; proposed changes in the levying of duties will probably tend to still further stimulate production. The newly organized Pomona Diamond Company, established as the result of an agreement entered into March 13, 1912, between Daniel de Pass & Co., of London, and the Pomona Mining Company, Ltd., of Berlin, will also prove an important factor in augmenting the German output, and the opinion has been expressed that before long 150,000 carats of diamonds per month may be provided from the German fields.[3] Present conditions are shown by the report of 19 shipments of diamonds from Lüderitzbucht and Swakopmund in the year 1911–1912, having a value of $4,960,000. The stones were as usual, small, averaging 6.52 to a carat, equivalent to an average weight of about 5/32 of a carat (0.16 of a new metric carat) for each stone.

The largely increased production of the German African diamond fields is shown by the fact that during the third quarter of 1912 the diamond production was 241,507 carats, and during the last quarter 370,258 carats, in all, 611,765 carats for the six months; in the last six months of 1911 the production was 372,775 carats, only about 2500 carats more than in the last *three* months of 1912.[4]

The production of the principal diamond mining companies in German Southwest Africa for 1910 and 1911 was as follows:[5]

| | 1910, Carats. | 1911, Carats. |
|---|---|---|
| Colonial Mining Co. | 312,684 | 277,246 |
| German Diamond Co., Ltd. | 135,038 | 130,291 |
| Diamond Lease Co. | 144,494 | ..... |
| Kolmanskop Co. | 146,653 | 147,233 |
| United States Mines of Lüderitzbucht | 57,331 | 54,376 |

These five companies are estimated to produce about 95 per cent. of all the diamonds from this field. The only notably successful one is the

[1] Jean Demuth, "Der Diamantenmarkt," Karlsruhe i.B., 1913, pp. 61–71.
[2] For details as to this field see the writer's articles on Precious Stones in the MINERAL INDUSTRY for 1908, pp. 732–734, and for 1911, pp. 629–631.
[3] See Report of Consul General Diederich of Antwerp to the Department of Commerce and Labor
[4] Deutsches Kolonialblatt for April 15, 1913.
[5] Jean Demuth, "Der Diamantenmarkt," Karlsruhe i.B., 1913, pp. 97, 98.

Colonial Mining Company, which was able to declare in 1910 a dividend of 2500 per cent. on its capital shares amounting to 100,000 marks; in 1911 the dividend was 2400 per cent. The Kolmanskop Company, with a low rate of operating expenses, distributed 55 per cent. in dividends in 1909, 45 per cent. in 1910 and 22 1/2 per cent. in 1911. On the other hand, the United Diamond Mines of Lüderitzbucht did not realize in 1910 profits warranting the declaration of any dividend.[1] Two companies suspended operations in 1911, Weiss, de Meillon & Co. in September of that year and the Swakopmund Diamond Co. in November.

On account of a regular increase in the size of the diamonds found as the search proceeds from north to south the proximate source of the diamonds is thought to be in the southern part of the field. In the northern part, at Spencer Bay, 0.1 carat is the usual size of the diamonds found, at Lüderitz Bay to the southward, 0.2 carat stones are plentiful, while in the Pomana district, still further south, 6 and 7 carat stones have been found and at Arch-rock, south of this again, a 17.5 carat diamond, the largest uncovered in this region, has been met with. This has led to the theory that these diamonds may have been washed down from original deposits in the interior of South Africa along the course of the Orange River, and then cast up on the coast by ocean currents, the prevailing southerly winds carrying the diamantiferous gravel toward the north, whereby the lightest diamonds were naturally borne farther away. An expected confirmation of this view by the finding of good-sized diamonds quite close to the Orange River has not, however, been realized.[2]

The proportion of diamond material in the gravels of the German Southwest African diamond field is greater than that of the South African mines, as regards the blue ground in which the diamonds are found there. In the richest of the Kimberley mines the ratio is 1:3,000,000, while 1:9,000,000 is considered good and even a proportion 1:36,000,000 admits of profitable working. In the German field, on the other hand, the proportion varies from 1:2,000,000 to 1:6,000,000; at the same time the expense of recovery is notably less, amounting on an average, to but one-quarter of that necessary in the South African mines. Apart from the difficulty experienced in securing proper native labor, the chief trouble with which the Germans have had to contend here has been the lack of water for mining operations, as well as for the use of the laborers.[3]

[1] Jean Demuth, "Der Diamantenmarkt," Karlsruhe i.B., 1913, p. 98.
[2] "Die südafrikanischen Diamant-Vorkommen," by Prof. Dr. Keiser, Bericht der Oberhessischen Gesellschaft für Natur und Heilkunde zu Giessen, *Naturwissenschaftliche Abteilung*, Vol. IV (1910–1911), p. 134.
[3] "Die südafrikanischen Diamant-Vorkommen," by Prof. Dr. Keiser; Bericht der Oberhessischen Gesellschaft für Natur und Heilkunde zu Giessen, *Naturwissenschaftliche Abteilung*, Vol. IV (1910–11), p. 35.

The following figures give the imports of diamonds to Berlin from the German African Protectorate, since the arrival of the first shipment on April 10, 1909. It will be noted that while there was a rapid increase in the number of carats, the average value per carat decreased because of smaller average size of the diamonds, owing principally to the substitution of machinery for hand work.[1]

| | Carats. | Value in Marks. | Value per Carat in Marks. |
|---|---|---|---|
| 1909–10 | 590,977 | 16,733,257 | 29.83 |
| 1910–11 | 798,865 | 21,389,465 | 26.775 |
| 1911–12 | 816,296 | 20,898,600 | 25.602 |

The progressive decrease in average size is stated to be: first year 13/64 carat; second year 11/64; third year 10/64 approximately, the number of stones to a carat being respectively 5, 5 3/4, and 6 1/2 in the several years.

The revenue secured by the German Government from the 33 1/3 per cent. export tax on diamonds from Southwest Africa in the three fiscal years (ending Feb. 29) 1910, 1911, and 1912 is given as follows:[2]

| | Marks. | In Dollars. |
|---|---|---|
| 1910 | 5,298,863 | $1,261,129 |
| 1911 | 6,773,328 | 1,612,052 |
| 1912 | 6,617,890 | 1,575,058 |
| | 18,690,081 | $4,448,239 |

The heavy export duty has operated to discourage mining in all but the richer and larger tracts. While it has been perhaps correctly urged that a check upon overproduction is not undesirable, the exclusive exploitation of the richer deposits tends to create large areas of comparatively unproductive gravels, and in order to render it profitable to mine these an eventual reduction of the duty will be imperative; probably the substitution of a tax on net revenue of 50 per cent., or even of 60 per cent., will prove to be the best solution of the problem.[3]

The rigid control exercised by the German Government has resulted in considerable revenue, but has not operated to improve the position of the shares. For example, the German Colonial Company's shares which were quoted at 190 in May, 1908, and had risen to 1850 by July, 1909, stood, after some fluctuations at 1815 in May, 1910; but from this date they fell steadily, their price being but 575 in August, 1912.[4]

[1] Dr. Kreuzkam, "Diamantenmonopol," *Die Umschau*, No. 34, August 17, 1912.
[2] Jean Demuth, "Der Diamantenmarkt," Karlsruhe i.B., 1913, p. 90.
[3] Jean Demuth, "Der Diamantenmarkt," Karlsruhe i.B., 1913, pp. 90–92.
[4] Jean Demuth, "Der Diamantenmarkt," Karlsruhe i.B., 1913, p. 75.

The German Diamond Regie renewed in 1912 its contract with the Antwerp syndicate that has for some time had a practical monoply of the product of the German diamond fields. This action was the subject of considerable opposition in Germany, public opinion favoring the selection of some German syndicate instead, especially that organized in Hanau. The matter was discussed before the Budget Commission of the Reichstag, and it was shown that the price per carat in the new contract had been advanced by 3 or 4 marks. There was a disposition to recognize the risks of experimenting in so important a matter as the sale of a million carats of diamonds annually, it not only being essential that the purchasing syndicate should be thoroughly responsible financially, but also that it should have the established trade connections insuring an eventual and profitable distribution of the diamonds it had acquired. Without an assurance of this there would be a danger of disturbing values, and little prospect that the arrangement with the new syndicate would be of a permanent character.

The approaching termination of the agreement now existing between the German Imperial Council Board and the Antwerp syndicate for the sale of diamonds from German Southwest Africa, is expected to bring out lively competition on the part of a number of groups eager to secure a new contract. That entered into with the Antwerp syndicate on March 30, 1912, was for 1,000,000 carats of diamonds, and official notice of its termination can only be given after 700,000 carats' weight have been furnished to this syndicate. The impression prevails that the Germans would favor a syndicate undertaking to open their sales bureau in Germany. However this innovation, a radical departure as to locality may not be found practicable. So far, the trade in uncut diamonds in Germany is very small.

As a preventive measure to forestall any possible attempt on the part of those connected with the De Beers Company, to gain control of the German Colonial Company by buying up its shares in the open market, Secretary Dernburg caused this company to issue additional capital stock to the amount of 2,000,000 marks, and to trustee these new shares in the hands of German holders.[1]

*Brazil.*—If the diamond mines of Brazil are no longer so productive as in the past, the memory of their former glories still casts a powerful spell over the minds of certain investors, if we can trust the reports in the press regarding the success—to the original projectors—of the many mining schemes that have been launched during the past few years. Indeed, it has been stated that from $6,000,000 to $8,000,000 has been lost in this way by the unwary. On the other hand, a holding company entitled

[1] Jean Demuth, "Der Diamantenmarkt," Karlsruhe i.B., 1913, p. 73.

"The Brazilian Companies," capitalized at $250,000, seems to have been managed in an entirely legitimate way. It is stated to own, directly or indirectly, an immense tract of mineral-bearing lands in Brazil, the control of this property having been acquired many years ago by Jay Gould during the reign of Dom Pedro. Gould is said to have contemplated the organization of a company to exploit these holdings, supposed to be rich, not only in diamonds, but also in gold and semiprecious stones. In one respect the managers of the "Brazilian Companies" show an altogether commendable prudence, as they do not undertake to mine the concessions on their own account, but simply lease out the rights to certain specified tracts for a royalty on the produce of the mines to be opened up.

There was a decrease of 75 per cent. in the exports of "carbonado" from Bahia, Brazil to the United States between the years 1910 and 1911. In the former year 1,108 carats of this material was exported with a value of $46,413, but in 1911 the exports fell away to 251 carats valued at $11,725.[1]

*British Guiana.*[2]—The diamond yield was notably greater in the year ending June 30, 1912, than in the previous year, and slightly exceeded that for the year 1909–10.[3]

| | Stones. | Carats. |
|---|---|---|
| Year ending June 30, 1910 | 77,695 | 6,319 |
| Year ending June 30, 1911 | 36,450 | 4,683 |
| Year ending June 30, 1912 | 81,034 | 6,977 |
| Year ending June 30, 1913 | 26,259 | 2,257 |

As in the first of these 3 years, the larger yield is represented by stones of smaller average size than in 1910–11. The source of these diamonds is given as follows for 1911–12.

| | Stones. | Carats. |
|---|---|---|
| Masaruni | 68,785 | 5,682 |
| Cuyuni | 12,230 | 1,290 |
| Wenamu | 19 | 5 |
| | 81,034 | 6,977 |

The total diamond production of British Guiana from April 1, 1900, to June 30, 1912, is stated to be 1,006,557 stones, weighing in all 74,203 carats. The average weight for 1912 is thus very low, less than 3/32 carat

[1] Consul S. P. Warner and Vice Consul O. E. Mueller in *Daily Consular and Trade Rep.*, December 18, 1912.

[2] See the writer's report on precious stones in MINERAL INDUSTRY for 1910, p. 574, and for 1911 p. 633.

[3] Gold, Diamond and Forest Industries of British Guiana, 1911–12.

(more exactly, .088 metric carat); in 1911 it was somewhat higher, 1/8 carat (0.128 metric carat).

The mining here is not systematically prosecuted; whether possible results would warrant the establishment of adequate machinery is uncertain, more especially in view of the difficulties of transportation to the out-of-the-way region where the diamonds are found. In 1910–11 diamonds to the value of $29,574 were exported ($300 worth to the United States); in the year 1911–12 the value of diamonds exported rose to $56,505, of which $1586 represents the value of those sent to the United States.[1]

*Dutch Guiana.*—A few diamonds are reported to have been found at intervals in Dutch Guiana, the most noteworthy of these finds occurring about 15 or 20 years ago at a mining concession on the Surinam River. It is stated by Mr. David E. Headley of Albina, Dutch Guiana, that 5 years ago, as manager of the Compagnie Française du Maroni, of St. Jean, he examined some conglomerates on the Maroni River which presented indications of being diamantiferous, and found one small octahedral diamond. Not long since a beautiful diamond was discovered in tailing piles at the scene of the recent cinnabar discovery on the Maroni River.[2]

*Canada.*—Some expeditions have been prospecting for diamonds recently in northern Quebec, especially in the blue clays and sand gravels along the banks of Matagami Lake. However, the expectation that they might harbor diamonds has proved fallacious, as might have been foreseen, for they are really blue clays and not decomposed peridotite as were the overlying diamond deposits of Kimberley. The clays of northern Quebec are alluvial deposits.

## Ruby and Sapphire

*Burma.*—Ruby mining in Burma is continued on about the same scale as in previous years. However, the report of the Burma Ruby Mines, Ltd., for February 29, 1912, states that, as a result of a satisfactory agreement made by the company with the Government in regard to the payment of indebtedness for unpaid taxes, the field of operations is to be enlarged at an eventual expense of about £20,000. This new mining ground is located in Kathé, a valley some 6 miles from Mogok. Here the existence of a considerable area of ruby-bearing ground has been determined, and fine sapphires have already been found, but the necessary opening out and draining of the valley and the installation of machinery

[1] Consul Hanna of Georgetown, in *Daily Consular and Trade Rep.*, Nov. 8, 1912.
[2] David E. Headley, "Diamonds in Dutch Guiana," in the *Eng. and Min. Journ.*, May 3, 1913.

will delay active operations for some time yet, although the work is well under progress.

In spite of continued depression in the London ruby market, the report of the Burma Company shows that during the year ending February 29, 1912, the sales of rubies amounted to £58,787 7s. 2d., as against £51,189 0s. 6d. in the previous year, an increase of £7598 6s. 8d. At the same time the value of the stock of rubies on hand increased from £56,809 to £62374. The profits for the year are figured at £7635 16s. 4d. of which the Government of India receives £2378 18s. 2d., leaving a net profit of £5256 18s. 2d., and making the total balance £22,021 9s. 10d. In view of these favorable results, the directors recommended the payment of a dividend of 6d. per share (4 1/6 per cent.) on the ordinary shares of the company, which would amount to £7475. The agreement with the Government to which we have alluded provides that the company shall not be required to make any payment on the amount due (£19,589) until its annual profits, after deducting the Government's share, shall exceed £18,000, equivalent to 10 per cent. on the paid-up capital. In such case, half of the excess must be paid to the Government until the indebtedness be liquidated. During the year 1,479,845 trucks of ruby earth were washed at a cost of 7.5d. per load (222,968 carats of rubies being secured) as against 1,466,136 loads at the same rate in the preceding year. The profit per load appears to have been equivalent to about 6.4 cents.[1]

It is gratifying to note that the operations of the Burma Ruby Mines for the year ending February 28, 1913, show essentially a continuance of the conditions noted above. The sales of rubies amounted to *L*65,647, 13s, 7d, an increase of £6,860, 6s, 5d over the previous year; the net profits were £5,340, 17s, 6d. This, added to a balance of £14,546, 9s, 10d, (after payment of last dividend), makes £19,887, 7s, 4d, from which it is proposed to pay another annual dividend of 6d per share, slightly reducing the balance as compared with that of the preceding year. The amount of ruby earth washed was 1,383,146 trucks, 96,699 trucks less than in 1911–1912; the average expense of washing increased .27d, amounting to 7.77d per truck.

The tract in the district of Mogok, Upper Burma, where ruby-mining is carried on, covers an area of some 45 square miles, but Mr. W. S. Lockhart, for many years the resident engineer of the Burma Ruby Mining Company, believes that the ruby-bearing region is much greater in extent, his estimate being about 400 square miles. There are three classes of mines. First, the pit or Twin-lone, which concerns the valley deposits, the bed of "byon," as the ruby-bearing soil is called by the

[1] *Daily Cons.* and *Tr. Rep.* November 19, 1912.

natives, appearing at a depth of from 15 to 20 ft.; here pits, or where the soil is a little stiffer, shafts are sunk and the "byon" extracted, after which it is washed in a series of troughs. The second classification bears the name "Hmyau-Dwin," or hillside mining, and is resorted to when the wet season interrupts operations in the valley bottoms, cuttings being made in the hillsides at such points as are thought to give promise of an underlying bed of "byon," which is here of a yellowish color and quite stiff, so that tunnels may be opened up through it; this hillside "byon" sometimes contains sapphires and tourmalines as well as rubies. To the third class is given the name "Loo-Dwin," or cave mines. Here the mining is done in widely ramified caves, whose entrance is clearly marked by outcrops of the limestone base of the mountains. The miner has to incur considerable risk in traversing the subterranean passages, but enjoys a corresponding reward in finding larger and finer rubies in the sandy "byon" of the caverns than are met with in other deposits. The chief improvements upon the old methods that have been introduced by the English company have been the use of power pumps to free the pits from water, and the treatment of the "byon" by rotating pans and a pulsator.

*Ceylon.*—A duty which is practically prohibitive has been imposed by the Ceylon Legislative Council upon all imitation and artificial precious stones, excepting imitation pearls and imitations in glass, by a resolution of September 9, 1912. This duty, which is a specific one, amounts to 100 rupees ($33) *per carat*, and is evidently designed to operate as an effectual bar to the importation of "reconstituted" or "synthetic" sapphires or rubies into this island. Heretofore the duty was only 5 1/2 per cent. *ad valorem*. Perhaps a danger of reexportation as genuine product of the Ceylon mines may be assumed as the guiding thought in this recent bit of legislation.

*United States.*—Sapphire has been greatly in demand during the past year, indeed, there has been a steady demand for it for some years. The sapphire working, in the Judith basin, Fergus Co., Montana, operated by the New Mine Sapphire Syndicate, furnished in 1912 about 90,000 carats of gem sapphire, the greater part of the output (478,405 3/4 carats) being only available for watch jewelling. The gem material ranged from 1/32 of a carat to three of four carats, no large pieces coming to light during the year.[1]

## EMERALD

In the Turner mines near Shelby, North Carolina, have been found a number of emeralds during the past year,[2] none of fine color or of any

[1] See for further particulars of this mining field writer's report for 1911, MINERAL INDUSTRY, XX, p. 641.

[2] For the geological conditions see the writer's report in MINERAL INDUSTRY, for 1911, p. 638.

great value. On this property, which is now owned and operated by Lovat Fraser and E. P. Earle, emerald material to the weight of 2700 carats had been found up to the middle of the year; out of this about 200 carats' weight of cut gems have already been made, and the balance of the material is expected to furnish gems weighing some 700 carats more. As is always the case with this precious stone, there is a very wide range in prices, depending upon the relative perfection of the gem, a fairly perfect emerald being always quite rare. Here the average value per carat has been approximately $15.

The name heliodor ("gift of the sun," from the Greek *Helios* and *dōron*) was bestowed on the stone by Prof. Lucas von Granach, a descendant of the famous sixteenth-century German artist of that name (1472–1553). A most graceful and patriotic gift recently made to the Empress by the German Emperor is a cruciform ornament composed of heliodors and brilliants in a platinum setting. This act of the Kaiser will be sure to make the new stone a favorite in Germany, whence the fashion will extend to other lands.

That German Southwest Africa hides other treasures of precious stones besides diamonds, is shown by the discovery of some fine beryls near the station of Rössing on the railway from Swakopmond to Windhuk.[1] They occur in pegmatite veins closely connected with parallel veins of rose-quartz and common quartz. The pegmatite veins are irregularly developed and often of small extent. The principal one is about 18 meters wide, the gem beryls only appearing in some 6 meters of this width at least as far as the vein has been examined, to a depth of somewhat over a meter; the other part offers nothing but common beryl. Most of the crystals are light green, the typical light aquamarine shade; some, however, are of a darker green and others again are bluish-green or yellowish-green. Recently a number of fine crystals of a light yellow hue have been found here, offering excellent gem material. Some of these have already come to Idar, where they have been cut and polished and have been placed on the market.[2]

While recognizing that there is no necessary connection between the coloration of the Madagascar beryls and their specific gravity, since the coloring pigment represents an almost imponderable quantity, M. A. Lacroix nevertheless remarks that the bluish and greenish shades are predominant among the beryls of lower specific gravity, and the pink shades among those of greater density.[3]

[1] Erich Kaiser, "Ein neues Beryll (Aquamarin)—Vorkommen in Deutsch-Sudwestafrika," *Centbl. für Min.*, etc., 1912, No 13, pp. 385–390.

[2] Gürich in *Neues Jahrb. für Min., etc.*, 1890, Vol. I, p. 114, and H. Thiene, "Ueber Apatit und Beryll von Tonkerhock," Centbl. für Min., etc., 1909, pp. 97–101.

[3] A. Lacroix, "Sur la continuité de la variation des propriétés physiques des beryls de Madagascar," *Bull. de la Soc. Franc. de Min.*, Vol. XXXV, June, 1912, pp. 200–208.

## Topaz and Tourmaline

An important deposit of gem topaz exists in Mason Co., Texas near the settlement of Streeter which is about 8 miles due west of the town of Mason, the county seat. The discovery here was made accidentally in 1904 by R. L. Parker of Streeter, who picked up one day in the bed of a stream what he at first supposed to be a quartz crystal. Its unusual weight, however, induced him to submit it for determination to a mineralogist, who pronounced it to be a crystal of topaz. A careful search at last revealed the source whence this specimen had been washed down, a pegmatite dike traversing a stratum of coarse red granite. Here the crystals appeared in cavities, associated with large crystals of flesh-colored microcline feldspar, biotite, small needles of black tourmaline, smoky quartz and albite (cleavelandite). Many of the topaz crystals are colorless, but some are blue and a few have the beautiful sky-blue shade of those from the Adunchilon Mountains, Siberia. The largest of these blue crystals measures nearly 3 in. in diameter and is of faint greenish blue. The fact that topaz is but little in demand for gem purposes has caused this deposit to be practically neglected for the past two years.[1]

The classification of tourmalines according to the presence or absence of magnesium oxide in their composition shows that those lacking magnesium are found principally in granitic pegmatites, with quartz, albite, orthoclase, microcline, muscovite, garnet, as well as often with lepidolite, beryl and spodumene. In hue these tourmalines are bluish black, blue, green, red or colorless, including the blue indicolite and the so-called lithium tourmalines. Those in which magnesium is present, on the other hand, are but rarely found in pegmatite veins, but occur commonly in metamorphosed rocks such as schists, metamorphosed limestones, etc., with quartz, biotite, phlogopite, augite, plagioclase, tremolite, etc., as accompanying minerals. They are of a black or brown color, rarely of lighter shade.[2]

## Other Minerals

The jadeite of Burma finds a ready market in China, whither nearly the entire output is sent. While this imported jade is chiefly handled in Canton, where the shops of the jade merchants occupy an entire street, the bulk of it reaches China by way of Hongkong whence it is brought to Canton. The material comes in large, vari-colored pieces, which are later divided into smaller pieces of uniform color. The value of the

[1] H. Conrad Meyer, "Topaz and Stream Tin in Mason County, Tex.; in the *Eng. and Min. Journ.*, Vol. XCV, No. 10, March 8, 1913, pp. 511, 512.

[2] Waldemar T. Schaller, "Beitrag zur Kenntnis der Turmalingruppe," Inaugural Dissertation, Leipzig, 1912.

jade imports, almost exclusively from Burma, has fallen off considerably since 1907, when it amounted to $348,987 in gold, as is shown by the following figures giving the value in gold of jade imports in recent years:

| | |
|---|---|
| 1909 | $131,433 |
| 1910 | 186,266 |
| 1911 | 106,511 |

The belief is expressed, however, that a considerable quantity of Burmese jadeite is brought into China by passengers and not entered for duty; indeed, it has been claimed that the total value of the jade which comes into China, regularly and irregularly, may be as much as $500,000, this estimate receiving a certain degree of confirmation from the fact that the value of the Burmese output, practically absorbed by China, has been estimated at a like figure. Little or none of this jade is reexported from China.

Chinese jewellers are said to apprehend that the modification of the old ceremonial dress due to the radical changes initiated by the new régime will exert a depressing influence on the Chinese jade market. The Burmese jadeite is still secured by means of the old, traditional methods which have so long prevailed, and it is thought that a change to modern methods might not result favorably, as a largely increased output would only serve to lower prices.[1]

Beads of chrysoprase strung for a necklace have been found on a mummy unearthed near Nasca, Peru. They are of a pale, greenish hue and are of especial interest as being, to the writer's knowledge, the first objects of chrysoprase ever found in a South American district. A string of over fifty beads was seen by Prof. Hiram A. Bingham, of Yale University, who submitted several to the writer for identification. They were believed to be emeralds.

The wood-opals from northwestern Nevada come from a part of Virgin Valley about 20 miles south of the Oregon boundary, and 40 miles east of the California State line. They occur in a stratum of dry clay having a thickness varying from a few inches to several feet. These opals are metamorphosed from trunks and branches of the Mountain Mahogany, the time of their formation being assigned to the Miocene period. The deposits, which are at an elevation of 5500 ft. were first discovered in 1909 by Mr. George Mathewson, and they have been more or less actively exploited since October, 1911, when Mr. M. Ivan Dow acquired an interest in them. Over $20,000 worth of opal material is said to have been extracted.[2]

The supply of opals, from the State of Queretaro, Mexico has been

[1] Consul General George E. Anderson of Hongkong, in *Daily Consular and Trade Rep.*, Sept. 23, 1912.

[2] For a full description of these opal deposits and of others in Idaho, Nevada and Washington, see the writer's report on precious stones in MINERAL INDUSTRY, for 1911, pp. 639–641.

somewhat irregular, owing to the mining operations, which have varied according to the demand for opals. The mines are owned by local syndicates and the stones are cut and polished in the towns of Queretaro and San Juan del Rio.

While Mexico City secures the finer grade of opals, a large quantity of the poorer material is exported to Germany. A disadvantage of many Queretaro opals is their great transparency as compared with those from either Australia or Hungary, so that in order to bring out their fire, which is in nowise lacking, resort is often had to artificial backing such as black velvet; sometimes, indeed, the natural backing of the matrix is preserved. Such stones, often rather irregular in shape, are called "matrix-opals." The Mexican opals are credited with greater durability than those from Australia, being less liable to injury from the slight, unavoidable accidents that sometimes happen in setting or wearing the gems; but it is asserted that they do not retain their brilliancy so well.

The opals are found near the top of a range of hills in a reddish-gray spherulitic rhyolite, forming the matrix. They were first noted, casually, about eight years ago, some exposed specimens showing their fire as the sunlight fell upon them. The presence, on the surface, of a white silicious sinter in cavities of the rhyolite, has been found to be an excellent indication of the existence of opal material; these appearances go by the local name of "pintas." How deep down the opaliferous rock extends has not yet been determined, but in some of the older mines opals have been met with at a depth of over one hundred feet. A few opals of rather poor quality have occasionally been found in Tlaxiaco, in Oaxaca, where the surface conditions seem to be quite similar to those obtaining in Queretaro.[1]

The sources of supply in New South Wales of the much-fancied Australian black opal appear to be exhausted, at least temporarily. Most of the miners have drifted away, and the chances of discovering new deposits are correspondingly lessened. It is reported in 1912 that the quantity of opal material of every kind from the Australian fields is 75 per cent. lower than at any time within the past twenty years. During 1911 opals to the value of about $300,000 were secured, $106,000 worth from the White Cliff district, the Wallangulla field in the Walgett division furnishing the remainder. The total value of the opals secured in Australia from 1890 to 1911 is estimated to be $6,529,377.[2]

A large mass of black opal from the Australian deposits is owned by a gem-dealer in Sydney, New South Wales. It weighs 4100 carats, or

[1] T. M. M. MacFarlane, "A Mexican Opal Mine," Informes y Memorias del Instituto Mexicano de Minas y Metalurgia, pp. 127–132; read at the Session of Aug. 7, 1911.

[2] "Opal Production in Australia." Report of G. H. Prosser, Consular Agent at Adelaide; *Daily Con.* and *Tr. Rep.*, Aug. 21, 1912.

about 2 lb. 3 oz. troy, and was found in 1912 in the Queensland mines by two exceptionally lucky miners and is valued at £10,000, or $50,000. It is confidently asserted to be the largest piece of black opal ever discovered.

Some pretty opals, semitransparent specimens, are found in the Hôko-tô group, Formosa, associated with chalcedony. They are sometimes blue as at Shôchikaku and Hattaku-tô, and sometimes gray as at Tsûryô, where resinous opal also has been observed.[1]

A valuable deposit of amethyst, the specimens extracted being of unusually fine quality, has been discovered in the Russian Transcaspian territories, 8 miles from Kereposti-Kushka.[2]

In 1906 a large deposit of moonstones of unusually fine quality and size, transparent and generally white, sometimes with a beautiful blue sheen if cut in the proper direction, was found in Ceylon at the village called Weragoda in the low-lying lands belonging to the Crown. The region is a mile and a half due east of the seacoast and fifty miles distant from the capital city, Colombo. The discovery of a new and rich deposit of this beautiful gem stone in Ceylon was more especially fortunate as the older deposits of Kandy and Wagawella had been nearly exhausted. Some of these are cut in Idar and Oberstein, in Oldenberg, Germany, but most of them are native cut with the quaint irregularity that has much charm. The great quantity of the material found here has led to a great revival and demand of this beautiful and inexpensive gem stone.

The mineral kornerupine was discovered in a gem form in Madagascar deposits in the southern part, about 20 miles grom Itrongahy in the direction of Betroka, and was described by Prof. A. Lacroix, of the Musee d'Histoire Naturelle, Paris. This mineral, with a hardness of 6.5, a specific gravity of 3.27, was formerly known from Fiskernas, Greenland, where it was associated with green amphibole, sapphirin, and with brown magnesian mica and gedrite, and iolite. It was named in honor of the Danish geologist, Kornerup. It was not in gem form in this locality, but in Madagascar it is transparent, and is wonderfully dichroic, with a green hue parallel to the vertical and a reddish brown perpendicular to this. It is here of a sea-green color, and has cut into beautiful gems weighing over two carats each. Kornerupine is a silicate of magnesia, alumina, and monoxide or sesquioxide of iron. One of the many interesting things is that it is responsive to radium $\beta$ and glows with a golden yellow, due evidently to the coloring matter described by I. Lorense.[3]

Specimens of thulite, of a rich rose-pink hue, resembling that of the

[1] T. Wada, "Beiträge zur Mineralogie von Japan," No. 4, Tokyo, June, 1912, p. 167.
[2] *Eng. and Min. Journ.*, Jan. 25, 1913.
[3] Medd Crône., July 19, 1884.

best rhodonite, have been reported as occurring in Okawagan Co., Washington State, at a point three-quarters of a mile distant from the line of the Great Northern Railroad. Here the material appears in large masses, in veins of from 2 to 5 inches in thickness. The mineral takes a fine polish.

*Amber.*—Nearly all the larger pieces of raw amber, mined or recovered by The Royal Amber Works near Königsberg in Prussia, are retained in Germany, but very few being disposed of to foreign importers. The so-called "amberoid," however, produced by the amalgamation of small fragments of raw amber under strong pressure after subjection to a temperature of 150° C., is exported in large quantities to the United States, especially forms in the shape of cigar-holders, mouthpieces for pipes, etc. As this material is really amber, though not in its natural state, we need not be surprised that only a trained eye can discriminate between amber and "amberoid." Several firms in the United States have special contracts with the Royal Amber Works, giving them the exclusive right to deal in its products. Pressed amber of this type is quoted at $26 per kilogram, or a little less than $12 per pound.[1]

## Pearls

Pearl fishing has not been carried on in Ceylon since 1907. The records of these fisheries go back as far as 306 B.C., at which date the Rajavali chronicle makes mention of them. A temporary exhaustion of the supply of pearl-oysters, followed by a renewal of favorable conditions, has not been of rare occurrence in the course of centuries. Indeed, the best returns have been recorded in the years succeeding such a period of unproductivity and this may perhaps again be the case.

The aid of science appears to have been rather ineffectual in stimulating, enlarging or directing exploitation, notably the use of the radiograph to determine which of the bivalves removed from the banks contained embryo pearls, the mussels being then returned to the water. All the mussels so treated died after being replaced in the water. Prof. Herdman discovered, in 1908, a large number of oysters, estimated to number over four millions, on the bank known as the Kondatchi Paar, which had been given up as exhausted. After only 650,000 oysters had been taken out by dredges and by native divers, the remainder were lost, or at least were not recoverable either in 1908 or in the succeding year.

The control and management of these fisheries are now, since the passing away of the Ceylon Co. of Pearl Fishers, in the hands of the Govern-

[1] Consul General A. M. Thacar of Berlin, in *Daily Consular and Trade Rep.*; for further details see the present writer's articles on Precious Stones in *The Mining Industry* for 1910, p. 588 and for 1911, p. 643.

ment, the master attendant of the port of Colombo acting as inspector of the pearl-banks, and the Government agent of the Northern Province as superintendent.[1]

A careful inspection of the rocky areas north of Colombo has been recommended by Capt. Kerkham, formerly superintendent of the Ceylon Company of Pearl Fishers, as he inclines to the belief that miniature oysters are often swept off the banks by the strong currents and carried to these rocky areas where they develop and then die of old age without their existence having been suspected by the pearl fishers.

The "paars" (oyster-beds or banks) suited for the development of the pearl-oyster are constituted by a coarse granite sand amalgamated with old oyster-shells by a cement of coral lime. This bottom insures a certain immobility to the coating of sand resting on it, while away from the "paars" the sand is heaved up and down so that any oysters resting on its surface are soon covered up and disappear.

Until about six years ago a pearl syndicate of rich Arabian and Hindu merchants in Bombay kept large stocks of pearls on hand and exercised a certain control over the world's pearl-market. This syndicate also acquired most of the output from the Persian Gulf fisheries. Formerly the contracts for purchases from these fisheries provided for payment of the principal only at the expiration of two or even three years, a large yearly interest payment being made, sometimes as much as 20 per cent. annually, a rate not relatively as high as it may seem to us, for 12 per cent. per annum is quite common in India. The object of this delay in payment was to give time for the pearls to dry out thoroughly, as when first taken from the mussel they often have a slightly greenish hue unfitting them for immediate use as ornaments. Recently, however, a Hindu chemist has improved and adapted the European methods of cleaning pearls so that now the same good results are obtained in a fortnight as were heretofore only possible in two or three years' time.[2]

Pearl farms are being developed in Lower California and more recently in Japan. Since the notable falling off in the supply of pearls from the Indian pearl-fisheries during the past few years the experiment of artificial pearl-culture has been worked out on a large scale in Japan, where the company known as the Mitsui Bussan Kaisha owns culture-pearl beds at Omura, on Omura Bay, containing, it is claimed, 200,000,000 pearl-oysters, 10 per cent. of which are expected to develop pearls of commercial value. The method of impregnation that has been elaborated by Dr. Nishikawa, of the Tokio Imperial University, has been employed

[1] "The Pearl Fisheries of Ceylon," by Consul Charles K. Moser, of Colombo, in *Daily Consular and Trade Rep.*, May 18, 1913.
[2] Léonard Rosenthal, "Le Diamant."

to a considerable extent in these Omura Bay beds. At least seven years' time, after impregnation of the pearl-oyster, is considered requisite for the growth of pearls.[1] In contradistinction the so-called culture pearls are not true pearls; they are merely hemispherical pellets of mother-of-pearl that were inserted in the pearl-oyster. And when they are coated with a thin layer of nearby nacre they are cut out and cannot be used in necklaces, because the sides show and they are only half-spheres. The Mexican pearl farm was much injured by a storm in 1912.[2] All pearl beds are subject to many dangers, as well as beds of edible oysters that are so firmly attached to heavy objects. Specially planted Japanese pearl beds and Cingalese beds of a similar nature have been so often subjected to such dangers that they have been known to pass out of sight in a night, having been swept away in great storms, or covered by great layers of sand. One cannot count with certainty on the safety of even the beds of edible oysters that are so firmly attached to heavy objects, as before mentioned.

The Mexican Government is reported to have cancelled the British "Mangara" concession; this opens up a field for independent fisheries on the coast of Lower California.

The Caddo Lake pearl fishery in Texas has lately been the object of some attention on the part of state legislators, with a view to secure the enactment of a law containing provisions for the control of this fishery and for the imposition of a state tax on the shells. The belief is expressed that a substantial revenue would result from the operation of such a law.

The abalone blister pearls produced by artificial means form a class by themselves, the method followed in stimulating their growth having been suggested by one of the chief causes of pearly excrescences on the inner surface of the abalone shell. It frequently happens that the shell of this mussel is invaded by a boring mollusk *Pholadidea parva*, which works its way into the abalone shell by cutting with the serrated edges of its own shell, this mechanical means being perhaps supplemented by the decomposing action of a secretion of sulphuric acid. When the *Pholadidea* has penetrated the shell until the pearly layer has been reached, the abalone seeks to arrest its further progress by secreting an unusual quantity of nacreous matter at this point, producing as the intruder forces its way in, a mound-like excrescence of pearly substance attached to the shell—the so-called blister-pearl. This occurs principally in the red abalones. This natural causation of blister-pearls suggested their artificial production by boring a hole in the shell and inserting in this a

[1] Vice-Consul Harold C. Huggins, of Nagasaki, in *Daily Consular and Trade Rep.*, July 5, 1913, p. 88.
[2] See "The Book of the Pearl," by George F. Kunz and Charles H. Stevenson, New York, 1907, pp. 41–72; 148; 288–293. Pearl Farm, Espirtu Santo, Mexico, p. 219, *loc. cit.*

form shaped like a long-shanked collar-button, the expanded bar being brought into contact with the mantle of the mollusk, while the shank projecting out of the orifice is made fast to the shell and tagged with a serial number or the date, so that when the mussel is taken out of the water again the exact length of time elapsed since this treatment may be immediately known.

Pearl-fishing near the port of Manta, Ecuador, is at present profitably carried on, pearls to the value of about $20,000 having been recently shipped thence to Europe. The Ecuadorian Government has bestowed upon one of its citizens, Senor Marco Aurelio Calderon, the exclusive right to pearl-fishing along the coast of Ecuador. From Peru also there seems good prospect of receiving pearls, as the latest reports state that some have been received near the port of Payta in that country.[1]

[1] Report of Vice-Consul Charles F. Baker, of Guayaquil, Ecuador.

# QUARTZ

The mineral, which is the most abundant constituent of rocks, is used in many different forms such as sand, quartzite, sandstone, flint and pebbles. The transparent mineral may have a gem value if perfect and of proper color, and is also used for optical purposes. The source of the latter kind is chiefly from Brazil in the form of pebbles. Flint is a compact tough silica occurring in nodules in chalk or limestone or in pebbles weathered from these. It is used largely in tube-mills and finely ground for paints (silex), pottery, etc., wood fillers, soap, etc.

Where feldspar is mined massive quartz is often produced from the pegmatite veins.

The production of quartz including only that used for pottery, paints, fluxes and abrasive was 97,874 short tons in 1912 valued $191,685 as compared with 87,943 tons valued 155,122 in 1911. The portion of this which was ground was 15,669 tons in 1912 and 10,184 tons in 1911. The production as given by the *U. S. Geol. Surv.* in recent years was as follows:

PRODUCTION OF QUARTZ IN THE UNITED STATES, 1908-1912, IN SHORT TONS.

| Years. | Crude. | | Ground. | | Total. | |
|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| 1908 | 26,478 | $37,319 | 20,838 | $152,838 | 47,316 | $190,157 |
| 1909 | 121,459 | 131,334 | 14,010 | 118,132 | 135,469 | 249,466 |
| 1910 | 49,886 | 80,984 | 13,691 | 112,773 | 63,577 | 193,757 |
| 1911 | 77,759 | 70,430 | 10,184 | 84,692 | 87,943 | 155,122 |
| 1912 | 82,205 | 67,256 | 15,669 | 124,429 | 97,874 | 191,685 |

The distribution among the states was as follows:

| State. | 1911. | | | | 1912. | | | |
|---|---|---|---|---|---|---|---|---|
| | Crude. | | Ground. | | | | | |
| | Short Tons. | Value. | Short Tons. | Value. | Short Tons. | Value. | Short Tons. | Value. |
| Connecticut, Massachusetts, and New York | 8,200 | $20,371 | 1,110 | $13,257 | 5,802 | $10,701 | 61 | $1,758 |
| Maryland | 4,738 | 8,244 | 3,239 | 26,042 | 10,130 | 15,369 | 5,995 | 46,782 |
| Pennsylvania and Tennessee | 49,381 | 32,015 | 1,500 | 9,750 | 66,049 | 40,486 | 1,200 | 7,800 |
| Other States(*a*) | 15,440 | 9,800 | 4,335 | 35,643 | 224 | 700 | 8,413 | 68,089 |
| Total | 77,759 | 70,430 | 10,184 | 84,692 | 82,205 | 67,256 | 15,669 | 124,429 |

(*b*) Includes Arizona, California, Michigan, and Wisconsin.

Prices of the crude material ranged from $1.25 to $2 per ton; the soft mineral as obtained in some western deposits falls below this limit. Ground quartz ranges from $4 to $60 per ton, the highest being for very finely ground quartz suitable for paints.

In Arizona and Tennessee smelting companies mined and used quartz; the Calumet and Arizona Mining Co. operated a quarry the ground product of which was used for lining reverberatory bottoms; the Tenn. Copper Co. increased its production, which is used for flux in smelting. In North Carolina the output of crude quartz from Fred Oliver's quarry, Mt. Holly, was used for packing acid towers. The Connecticut output from the one producer A. P. Freeman of Canaan was used for abrasive paper. In Maryland six producers supplied a variety of markets. The producers are: Indian Rock Flint Co., Conowingo; Husband Flint Milling Co., Baltimore; Thomas & Son, Westminster; Maryland Flint Co., Williamsport, Pa.; Guilford & Waltersville Granite Co., Baltimore; and H. Clay Whiteford & Co., Flintville.

The Massachussets output is used for soap and powder and for facing cement blocks; the producer is the Enos Adams Co. with a mill near Cheshire. Pennsylvania's output was from the quarries of the Columbia Flint Co. near Bendersville, and that of H. T. A. Rhodewalt at Cornog station. The Wasau Quartz Co. in Wisconsin continue to produce a quartz for filtering sand, for roofing, etc. The Quartz Glass Manufacturing Co. of Los Angeles, Calif., now produces a milled quartz for all purposes. The Michigan Quartz Silica Co. of Ishpeming continues to make the product for paint.

### Foreign Countries

The production of foreign countries in the order of importance is Canada, Sweden, Norway and Italy. The Canadian production for 1912 as reported by the department of mines is 100,242 tons valued at $195,216.

### Siliceous Products and Uses

*Silex.*—Good silex[1] is used as a filler in paints, and when pure is preferable to mixtures with clay which lack transparency. The silex is the material obtained from flint by grinding, whereas other qualities of silica, obtained from sand, quartz or water glass, are usually designated as silica. Silica adds porosity to paint, and is more beneficial than the use of barytes as it carries more oil. Silica requires from 30 to 32 lb. of oil for 68 to 70 lb. of fine floated silica to make a medium paste. When mixed and

[1] *Oil, Paint and Drug Reporter*, April, 1913.

ground with pigments of lowest specific gravity, it holds well in suspension and does not cake.

*Flint.*—Pebbles are imported into the United States free. The imports are distributed as follows for the year 1912:

| | | | |
|---|---|---|---|
| Belgium | $99,472 | Germany | $67 |
| Canada | 14,141 | Norway | 239 |
| Denmark | 78,123 | | |
| England | 870 | Total | 292,052 |
| France | 99,140 | | |

The chert and flint produced in the United Kingdom in 1910 was 73,904 tons valued at £12,795; in 1911, 71,557 tons valued at £14,074. The chert obtained principally from carboniferous strata in Derbyshire and Flintshire is used for grinding in the Pottery industry. Flint is mainly obtained from open chalk pits. Flint gravel is not included in these figures.

*Rock Crystal and Agate, Etc.*—During 1912 the imports of agate were valued $27,562; and rock crystal $7526; these are dutiable at 50 per cent.

*Ferro-silicon.*—Silicon in this product of the electric furnace ranges from 10 to 80 per cent.

Ferro-silicon if over 15 per cent. Si is dutiable at 20 per cent.; if under at $5 per ton. The imports into the United States in 1912 were 489 tons valued 446,456 of the higher silicon content. Ferro-silicon is used in increasing quantities in steel manufacture as a deoxidizer. Germany imports large quantities; in 1911, 38,317 tons, chiefly from Switzerland and Norway.

Ferro-silicon produced in Norway in 1912 amounted to 7000 tons valued $272,020; the exports were: to the United States, 200 to 300 tons; to the Netherlands, 3000 tons; to England, 500 tons.

The ferro-silicon production in Norway has not increased very much in recent years, as is shown by the following table of exports:

| | |
|---|---|
| 1909 | 2,645 tons |
| 1910 | 5,121 tons |
| 1911 | 5,745 tons |
| 1912 | 6,493 tons |

Low prices due to over-production are complained of, but the demand from the United States promises greater exports in 1913.

Italy at one works in 1910 produced 1692 tons valued 925,260 lires, and at three works in 1911 produced 1809 tons valued 496,215 lires. The alloy of manganese and silicon is produced from one works; in 1911, 60 tons produced of this alloy were valued at 21,000 lires.

Sweden produces and exports this alloy under stringent regulations for packing. The following statistics are available: 1907, 2537 tons; 1908,

1510 tons; 1909, 1311 tons; 1910, 4577 tons. About one-half of this went to the United States in 1910, one-fourth to Great Britain, and one-eighth to European Russia. Other nations interested are Germany and the Netherlands, each of which took about 5 per cent. of the total. The proportion exported through Goteborg has risen from 40 per cent. in 1907 to about 95 per cent. in 1910. In 1911 Sweden produced 1058 tons of ferro-silicon and 436 tons of manganese ferro-silicon, at Trollhaettan; 1950 tons of ferro-silicon at Gullspang, and 607 tons at Kortfors; at Domnarfvet 213 tons of ferro-silicon and 15 tons of manganese ferro-silicon were produced, making a total of 3828 tons of ferro-silicon and 451 tons of manganese ferro-silicon.

The sale of ferro-silicon (10 per cent.) in Belgium for prompt shipment from England is at 110s. per long ton.

*Fused Silica.*—Fused silica is produced by melting quartz sand in an electric furnace; the material is made into chemical apparatus on account of its resistance to acids and fusion. The conductivity for heat is an advantage, but the roughness of its surface is said to prevent satisfactory cleaning for some operations.

The quartz tube high pressure mercury arc lamp has had fairly extended use in Europe. Tungsten wire can now be used instead of platinum for sealing in with special high temperature glasses, these grading in quality between the tungsten and the quartz.

The export value of silica ware from Newcastle on Tyne to the United States in the year 1910 was $11,567, and in 1911, $9538.

*Tripoli and Pumice.*—Siliceous materials such as infusorial earth, tripoli and pumice, are largely used as abrasives. Tripoli is a light porous siliceous rock, supposed to result from leaching calcareous material from a siliceous limestone. Tripoli is produced in Illinois and Missouri. The composition of infusorial earth is more nearly pure silica; it is produced in California, Connecticut, Georgia, Maryland, Nebraska, New York and Virginia. The imports of this material and those of Tripoli come under the head of "Rotten Stone." The value of the imports of this class into the United States are as follows:

| | |
|---|---|
| 1908 | $ 17,252 |
| 1909 | 24,024 |
| 1910 | 56,657 |
| 1911 | 35,665 |
| 1912 | 24,253 |

The production in the United States, as given by the United States Geological Survey, for the corresponding years are as follows:

| | |
|---|---|
| 1908 | $ 97,442 |
| 1909 | 122,348 |
| 1910 | 130,006 |
| 1911 | 147,462 |
| 1912 | 125,446 |

The annual production of these materials probably averages 15,000 short tons.

One of the siliceous materials used as an abrasive is pumice stone. The domestic product is almost entirely finely comminuted volcanic dust or "ash." The imported material from Italy is a massive rock with fine vesicular structure. The production of pumice in recent years, as given by the United States Geological Survey, is as follows.

| Years. | Short tons. | Value. |
|---|---|---|
| 1908 | 10,569 | $39,287 |
| 1909 | 15,103 | 33,439 |
| 1910 | 23,271 | 94,943 |
| 1911 | 21,689 | 88,399 |
| 1912 | 27,146 | 86,687 |

The value of the imports into the United States are as follows.

| | |
|---|---|
| 1908 | $ 67,094 |
| 1909 | 100,997 |
| 1910 | 104,425 |
| 1911 | 118,977 |
| 1912 | 74,478 |

Some of the domestic rock is used for building purposes but is not included in the production.

The production of pumice in Italy from twelve establishments in 1911 was 19,600 tons. From Italy during 1912 there were exported 27,944 metric tons of pumice to the following countries: United States, 8360; England, 3500; Belgium, 3064; Germany, 8100; Austria, 900; Italy, 1000; Netherlands, 1820; Spain, 200; France, 1000. On the Lipari Islands there are 30 mines, each employing 15 to 20 persons. Low prices rule in 1912, and sales toward the close of the year to the United States fell off. Trade conditions are depressed and the large mills in operation were carring large stocks early in 1913. The import duty on pumice into the United States has some effect on this industry. The duty on unmanufactured pumice valued at less than $15 per ton is 30 per cent., and on that valued at more than $15 per ton is $5.60 per ton. Manufactured pumice imported into the United States is dutiable at 3/8 cent per pound.

The amount of pumice stone produced in 1911 in New Zealand was 3151 tons valued at £7948. Of this 555 tons are pumice sand valued at £1347.

*Properties of Quartz.*—The insulating properties of silica in experiments by C. P. Randolph at a temperature of 500° C. is found to be 154° C. per watt per cubic inch. Quartz is found to have the thermal resistivity in the same units of 6.0. Ordinary coarse sand will stand tempera-

tures of about 1500° C., with a thermal resistivity of 150°. Silex, which is composed of extremely finely ground silica, resembling flour, will stand 800° C. without shrinking and shows thermal resistivity at 500° of 387 units. The thermal resistivity of silica brick fired at a temperature of 1050°, at 1000° is 47° C. per watt per cubic inch.

The melting-point of pure silica[1] is determined as 1750°; this is given as the temperature at which it flows distinctly.

[1] C. W. Kanolt, *Eighth Intl. Congr. Appl. Chem.*

# QUICKSILVER

The production of quicksilver in the United States increased considerably in 1912, although the number of producing mines was less. The production in the United States was 25,147 flasks in 1912.[1] The greatest increase in production is recorded in California, chiefly on account of the yield of the New Guadalupe Mine in Santa Clara County. The largest producer in America is, as heretofore, the New Idria, in San Benito County. The amount of ore treated in 1911 was 282 tons in retorts, and 138,243 in shaft furnaces, yielding respectively 172 and 21,084 flasks. The yield of metal, therefore, was 46 lb. in retorts and 12 lb. in shaft furnaces per ton of ore treated. The imports of quicksilver were in considerable excess over the exports. Quicksilver is dutiable at 7 cents per pound. The statistics are given in the following table:

STATISTICS OF QUICKSILVER IN THE UNITED STATES.

| Year. | Production. | | | | | Exports. | | | Imports. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Calif. (a) | Texas. | Others. | Total. | Value. (f) | Flasks. | Metric Tons. | Value. | Pounds. | Value. |
| | Flasks. | Flasks. | Flasks. | Metric Tons. | | | | | | |
| 1898 | 31,092 | (b) | 153 | 1,077 | $1,194,746 | 12,830 | 445 | $440,587 | 81 | $ 51 |
| 1899 | 29,454 | 261 | ..... | 1,025 | 1,416,790 | 16,518 | 573 | 609,586 | 131 | 83 |
| 1900 | 26,317 | 1,700 | 233 | 974 | 1,279,436 | 10,702 | 353 | 425,812 | 2,616 | 1,051 |
| 1901 | 26,720 | 2,932 | 75 | 1,031 | 1,382,305 | 11,219 | 389 | 475,609 | 1,441 | 789 |
| 1902 | 29,552 | 5,252 | ..... | 1,208 | 1,515,714 | 13,247 | 459 | 575,099 | *Nil.* | ..... |
| 1903 | 32,094 | 5,029 | ..... | 1,288 | 1,564,734 | 17,575 | 610 | 719,119 | *Nil.* | ..... |
| 1904 | 28,876 | 5,336 | 700 | (c)1,204 | 1,348,185 | 21,064 | 731 | 841,108 | 212 | 160 |
| 1905 | 24,655 | 5,000 | 1,050 | 1,045 | 1,217,652 | 13,460 | 458 | 497,470 | 2,690 | 1,710 |
| 1906 | 19,516 | 4,517 | 1,276 | 861 | 1,035,138 | 6,455 | 220 | 244,299 | 84 | 50 |
| 1907 | (d)17,532 | 3,000 | 400 | 712 | 868,678 | 5,132 | 175 | 192,094 | 16,566 | 6,719 |
| 1908 | (d)16,969 | 2,832 | 346 | 685 | 903,391 | 2,995 | 110 | 124,960 | 15,113 | 8,215 |
| 1909 | 16,217 | 4,188 | 810 | 704 | 941,233 | 6,803 | 231 | 266,243 | 15,968 | 8,203 |
| 1910 | (d)18,536 | 3,382 | 500 | 763 | 1,054,991 | 1,923 | 65 | 91,077 | 667 | 381 |
| 1911 | 18,860 | (g)2,396 | ..... | 732 | 989,254 | 291 | 10 | 13,995 | 471,944 | 251,386 |
| 1912 | 20,600 | 2,700 | 1,847 | 855 | 1,067,742 | 310 | 14 | 13,360 | 82,706 | 39,919 |

(a) Reported by the California State Mining Bureau, except 1907–08–10–11. (b) Included in "Other States." (c) Estimated; the weight of the flask was changed from 76.5 lb. to 75 lb. within this year. (d) Figures collected by the MINERAL INDUSTRY. (f) Computed at average price at New York. (g) With Nevada.

*Prices.*—For American quicksilver, San Francisco is the primary market. The quotations in New York are usually $3 above those of London. The market in 1912 was active. It is well known that the

[1] *U. S. Geol. Surv.*; Mineral Resources, 1912.

product of our western mines, especially those of California, is sold under a pooling arrangement. The following table gives the American prices:

QUOTATIONS FOR QUICKSILVER IN LARGE LOTS.
(Per Flask of 75 lb.)

| Month. | 1909. | | | 1910. | | | 1911. (a) | | | 1912. (a) | | | London. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | New York. | San Francisco | | New York. | San Francisco | | New York. | San Francisco | | New York. | San Francisco | | |
| | | Domestic. | Export. | | Domestic. | Export. | | Domestic. | Export. | | Domestic. Sales. | For Export. | |
| | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ | $ | £ |
| Jan. | 45.50 | 45.30 | 43.30 | 52.20 | 50.90 | 48.90 | 42.00 | 41.63 | 39.63 | 43.00 | 42.50 | 40.00 | 8.60 |
| Feb. | 45.50 | 45.50 | 43.50 | 50.00 | 49.50 | 47.50 | 48.69 | 48.00 | 46.00 | 45.50 | 44.63 | 41.13 | 8.35 |
| Mar. | 45.50 | 44.75 | 42.75 | 49.25 | 48.75 | 46.75 | 52.00 | 51.00 | 49.00 | 44.60 | 44.10 | 41.60 | 8.53 |
| Apr. | 45.00 | 44.25 | 42.25 | 48.00 | 47.56 | 45.56 | 49.40 | 48.90 | 46.40 | 42.06 | 41.75 | 39.75 | 8.54 |
| May. | 44.50 | 44.00 | 42.00 | 47.60 | 47.15 | 45.15 | 45.00 | 44.50 | 42.00 | 41.56 | 41.50 | 39.00 | 8.25 |
| June. | 44.50 | 44.00 | 42.00 | 47.00 | 46.25 | 44.25 | 43.75 | 43.44 | 40.94 | 41.40 | 41.30 | 38.80 | 8.30 |
| July. | 43.75 | 43.44 | 41.44 | 47.00 | 46.25 | 44.25 | 48.00 | 47.60 | 45.10 | 42.50 | 42.00 | 39.50 | 8.50 |
| Aug. | 43.75 | 42.95 | 40.95 | 46.00 | 45.88 | 43.88 | 48.25 | 47.63 | 45.13 | 42.38 | 41.88 | 39.38 | 8.06 |
| Sept. | 45.00 | 43.50 | 41.50 | 46.00 | 45.50 | 43.50 | 46.88 | 46.50 | 44.00 | 42.00 | 41.50 | 39.00 | 8.05 |
| Oct. | 47.00 | 45.90 | 43.90 | 45.80 | 45.40 | 43.40 | 45.20 | 44.70 | 42.20 | 42.03 | 41.50 | 39.00 | 8.00 |
| Nov. | 52.50 | 50 75 | 48.75 | 43.88 | 43.50 | 41.50 | 45.00 | 44.50 | 42.00 | 42.03 | 41.50 | 39.00 | 7.63 |
| Dec. | 52.50 | 51.00 | 49 00 | 42.00 | 41.50 | 39.50 | 44.25 | 43.75 | 41.25 | 40.50 | 40.40 | 37.90 | 7.42 |
| Year. | 46.30 | 45.45 | 43.45 | 47.06 | 46.51 | 44.51 | 46.54 | 46.01 | 43.62 | 42.46 | 42.05 | 39.55 | 8.14 |

(a) From *Eng. and Min. Journ.*

The London quotations are given in the last column for 1912.

*California* (By Lewis H. Eddy).—The production of quicksilver in California in 1912 amounted to 20,600 flasks of 75 lb., of an average value of $42.04 per flask, or a total of $866,024. This is an increase over 1911 of 1491 flasks, but a decrease in value from $46.01 per flask. There was a decrease in the production in the large mines in San Benito County, but an increase in Santa Clara County. The Idria produced about 10,000 flasks; the mines in Santa Clara County about 7400 and the smaller mines of Lake, San Luis Obispo, Napa, Sonoma, Trinity and Colusa produced an aggregate of about 3200 flasks. The State Mineralogist reports the following production by counties:

| County. | Flasks. | Value. |
|---|---|---|
| Colusa | ..... | ..... |
| Fresno | 336 | $14,125 |
| Lake | 209 | 8,786 |
| Napa | 287 | 12,065 |
| San Benito | 9,743 | 409,596 |
| San Luis Obispo | 666 | 27,998 |
| Santa Barbara | ..... | ..... |
| Santa Clara | 8,695 | 365,538 |
| Sonoma | 646 | 27,158 |
| Trinity | 18 | 758 |
| Total | 20,600 | $866,024 |

New discoveries and extensive development are accountable for the increase over 1911. New development work was done at both large and small mines, and cinnabar discoveries of encouraging quantity and value were reported. The New Idria gave more attention to development than to increased production, owing to low prices and to absence of special demand for income from sales. The report for 1912 of the New Idria Quicksilver Mining Co. states that during the year, 76,348 tons of ore were reduced, and 9600 flasks of quicksilver were produced.

In Santa Clara County both the Guadalupe and the Almaden opened new ore-bodies and made improvements in the mines, and had prices been better the increase in production would no doubt have been larger. The Guadalupe made great advances in 1911 and still greater in 1912, and the Almaden is reported to have improved largely in 1912. The prospect, known as El Dinero, near the Guadalupe, made gradual improvement during the year. More attention was given to the exploration of the ground than to development of the known deposits. Preparations were made for economical and profitable development when prospecting shall warrant it.

The small mines in the south and north are reported to have produced a total of 1200 to 1500 flasks in the year, although not all of them were operated regularly. This was an increase over the production of 1911, and resulted from increased activity of the owners, who desired present small profits rather than future possibility of larger profits. Some sales were reported to have been made to large producers instead of direct to the market. In the northern part of the state, production increased at most of the operating mines, except the Great Western, and there was a small aggregate production from the irregular working of others. In the southern end of the quicksilver belt the production was chiefly from San Luis Obispo and San Benito Counties. The small mines in San Benito, southwest of Idria, produced several hundred flasks in 1912, and were preparing at the close of the year to increase furnace capacities, apparently warranted by the results of development. One of these mines, the Hernandez, formerly known as the Ramires, was taken over by a new company. Some prospecting and partial development occurred at other properties in the counties south of San Francisco, but no commercial production was reported. There are numerous deposits of cinnabar in several counties that have not been thoroughly prospected. The industry could be greatly improved by judicious prospecting and the development of promising small properties. Few of the owners of idle cinnabar claims are practical quicksilver miners, and the organization of stock companies for the prospecting and developing of small mines or new claims was not so easy to accomplish in 1912 as in former years.

*Texas* (By Wm. B. Phillips[1]).—During the year there were no remarkable changes in the industry. The Chisos Mining Company continued to be the only one in operation. The idle furnaces were:

Two 10-ton, Marfa & Mariposa.
One 50-ton, Terlingua Mining Co.
One 10-ton, Colquitt-Tigner.
One 20-ton, Texas Almaden.
One 50-ton, Big Bend.

The Scott furnace of the Chisos Mining Company has a daily capacity of 15 to 20 tons of ore carrying from 1.5 to 2 per cent. of metal. The deepest shaft of this company is down below the 500-ft. level and has penetrated the underlying Buda limestone, in which is found the same character of ore as was mined in the overlying Eagle Ford shales. The workings of this company have been confined, for the most part, to the members of the Upper Cretaceous, while those of the companies that worked farther west were confined to the Lower Cretaceous (Edwards and Washita limestones). Both the Lower and the Upper Cretaceous in this general district have been productive of excellent quicksilver ores. The total thickness of the ore-bearing limestones of the Lower Cretaceous is from 1000 to 1200 ft., and probably somewhat less for the shales, etc., of the Upper Cretaceous. A new discovery of the rich oxy-chlorides of quicksilver (terlinguaite, eglestonite and montroydite) was made on Section 40, Block G. 12, in the Edwards limestone, property of the Terlingua Mining Company. The discovery was made by James Lafarelle, one of the best prospectors in the district, within 2 ft. of the surface and within a short distance of the pit from which 150 lb. of fluid quicksilver were taken several years ago, from a single cavity in the limestone.

The oxy-chlorides were found impregnating a ferruginous and somewhat greasy clay and also as lining the cavities of ovoid nodules containing much oxide of iron. On the same section there has been found a brilliantly scarlet cinnabar which turns quite black on exposure to the sun and air. This black "azogue," when present as small particles in shale or limestone, is known among the Mexican prospectors as carga de la musca. It has often been overlooked by prospectors not familiar with this kind of quicksilver ore. The yellowish-gray stains and streaks of terlinguaite are also often passed by.

Up to the close of 1912 the total production of quicksilver in the Terlingua district was about 50,000 flasks, valued at more than $2,000,000. The first production was credited to the year 1899, 1000 flasks. The

[1] Director, *Bur. Econ. Geol. and Tech.*, Univ. of Texas, Austin.

high water mark was reached in 1904, with 5336 flasks. Since that time the production has declined and is now, 1912, about 2700 flasks.

The Terlingua district, southern part of Brewster County, including the limestone and the shale areas, has been characterized by very rich pockets and chambers of ore. Some of these chambers in the limestones have yielded from $15,000 to $20,000 worth of cinnabar. Very few of the workings have reached a depth of 50 ft., most of the ore having come from above this level. The district has not been distinguished by systematic mining, the Marfa & Mariposa Mining Company and the Chisos Mining Company being honorable exceptions. The methods adopted have been crude and wasteful, consisting of open pits, trenches and shallow shafts. The purpose seems to have been to make as much money as possible within the shortest possible time, without regard to the future. The consequence is that more than one good property has been brought into a wretched condition. There is more than one property idle to-day that would supply ore of 1.5 to 2 per cent. of metal under systematic mining. When one considers that the average content of the California ores is about 0.75 per cent. in metal, an ore that carries from 1.5 to 2 per cent. should certainly be attractive. There is no good reason to suppose that these ores will fail in depth or in quality. Wherever they have been mined in depth, 500 to 600 ft., they have been found to be continuous and of regular content in metal.

*Other States.*—No production came from Arizona, Oregon, Utah or Washington. In Nevada the output in 1912, from the Mercury mine, in Nye County, was largely increased; a modern Scott furnace was put in operation. A small production was also reported from the Telluride mine, near Beatty, Nevada. Some deposits are reported from Bare County and a few other localities. In Arizona, the Sunflower Cinnabar Mining Company is preparing to work the property in the Mazatzal Mountains, northeast of Phoenix.

## Foreign Countries

*Austria.*—Six enterprises for mining the ore exist in the country, but practically only the State mines at Idria were operated during 1911. The employment of 958 persons, forty-one less than in 1910, produced 111,018 metric tons of ore, an increase of 10 per cent. over 1910. This ore was valued at the mines at $4.85 per metric ton.

The furnaces of the Government employed 225 men and the production of the metal was 704.124 tons, an increase of 14.4 per cent. over 1910. Though the average value of this quicksilver was less per ton than in 1910, the total value was 10 per cent. greater, being 3,816,352 K. ($763,270) in 1911.

The mine in Karnten at Paternion, belonging to the Mercur Company, is now transferred to Franz Zmerzlikar, Engineer.

At Idria the material treated during 1911 consisted of 40,617 tons poor lump ore, 66,659 tons poor fines (Erzgriese), 3740 tons rich fines, 43.4 tons (Stupp) and 613 tons of débris from old furnaces. The fuel used during the year consisted of 3471 cu. m. of charcoal, 12,967 of kindling wood, 2033 tons of lignite and 11 tons of coke; the total value of this fuel was $33,700. Sixty tons of the quicksilver produced was used locally for chemical manufactures.

*Canada.*—Nothing new is known of discoveries in Northern Ontario. At the Nipissing High Grade Mill, R. B. Watson[1] determined that the silver ore contains from 2 to 5 lb. of mercury per ton. The content of metallics was found to vary from 8 to 95 lb. of mercury, the average of 21 samples being 35 lb. per ton. When the refinery was built, the first charge of 1 ton of metallics produced a small bottle of mercury and globules were found in the flue-dust.

*Dutch Guiana.*—Water-worn pebbles of cinnabar were found while washing for gold, on the Maroni River. The result of examinations by engineers have not been made public.[2]

*Germany.*—The price of mercury in Germany was stated about 150 marks per flask of 34.5 kg. The mercury imported in 1911 was 919 metric tons, whereas the exports were 36 tons in 1911, and 37 tons in 1912. The cinnabar red exported from Germany in 1911 amounted to 149 tons valued at $164,220.

*Italy.*—There are nine plants producing ore in Italy, and the production was as follows: 1910, 87,129 tons valued at 3,729,352 lires; 1911, 97,803 tons valued at 4,664,597 lires. Six works produced in Italy, in 1910, 893 tons of quicksilver valued at 5,360,897 lires; eight works in 1911, 955 tons valued at 5,252,500 lires. In 1912, 88,200 tons of ore yielded 1000.4 tons

*Japan.*—The production of mercury in Japan is very small, being reported in 1911 as 408 kg. The imports of cinnabar and vermillion in 1910 were 90,100 lb. valued at $42,700. Nearly all of this material comes from China.

*Mexico.*—The quicksilver mines at Guadalcazar have installed a new 10-ton furnace and are handling about 50 tons of ore per week. At

[1] *Eng. and Min. Journ.*, Dec. 7, 1912.
[2] J. Robles, Albina, Dutch Guiana, *Eng. and Min. Journ*, April 19, 1913.

Cedral, old Spanish tailings from the old patio process are being worked over for quicksilver with some success.

The quicksilver from San Luis Potosi, exported to the United States, was valued at $13,989 in 1911. It is produced at Guadalcazar about 50 miles northeast of the capital, and also at Moctezuma, more to the west.

At the Guadalcazar the country rock is chiefly blue limestone with the usual intrusions of porphyry. It was a rich producer of quicksilver 70 years ago, when the product was in great demand for the amalgamation process of silver extraction. The present output is not more than 500 flasks per annum. The sulphoselenide of mercury, known as guadalcazarite, is found here. A 10-ton MacTear muffle furnace has recently been installed. The cost of mining labor in this section is about 32 cents per day.

South a few miles from Charcas are the quicksilver deposits of Venado and Montezuma. These mines date back only to 1894 and consist of the Dulce Nombre, Guadalapana, and Purisima, which are producing on a small scale and have two 5-ton MacTear furnaces.

Quicksilver has been mined near Santa Maria, some 30 miles southeast of the city of San Luis Potosi, the ruins of old Spanish workings being found in that vicinity. Efforts to revive production in that locality have not yet resulted in commercial importance.

The output of quicksilver in Mexico during 1912 was less than 120 tons. The output had fallen in 1911 to 95 tons, whereas in 1910 and previously it was about 200 tons per year. During 1911 the quicksilver declared for export to the United States in Mexico City was $41,992.

The quicksilver exports from Mexico during the fiscal year 1912, were as follows: To Germany 24,887 kgs.; to Belgium, 4,000 kgs.; to the United States 39,421 kgs.; to France 14,790 kgs.; to Great Britain 51,587 kgs.; a total of 134,685 kgs., valued at 273,066 pesos.

*New Caledonia.*—A number of cinnabar mines are not worked[1] because the mineral laws permit the retention on the part of the holders of land of the ore deposits. The deposits are found principally at Bourail and upon the east coast at Nakepy, Canala, Kouaoua and Piwaka. The tenor of metal is stated to be from 1.75 per cent. to 2.75 per cent. mercury in the ore.

*Peru.*—The famous old Huancavelica mine is worked to some extent by "busconeros."

[1] *Bulletin du Commerce*, Noumea.

*Russia.*—The promising deposits of quicksilver have been found in the Urals, in the Verch Isset district, 20 miles from Neviansk, on the Perm railway. Samples show 10 per cent. of mercury. The average of 57 samples, however, was 0.61 per cent.

The only quicksilver mines being worked are those of Auerbach & Co., in the Ekaterinoslaff government. The cinnabar occurs in sandstone and partly in quartzites underlying the sandstone. Stibnite and sulphur are associated.

*Spain.*—The production of quicksilver ore in Spain in 1911 from twenty-eight mines was 19,940 tons valued at 3,527,003 pesetas at the mine; 1384 men were employed in this industry. The Province of Granada has twenty mines, producing from an acreage of 1368. Other quicksilver mines are in the Province of Almeria. The production of quicksilver in 1911 was 1486 tons, against 1000 tons in 1910.

*Turkey.*—The last official report of the Department of Mines and Forests of Turkey, is for the fiscal year ending March, 1909: In 1908, 98 1/2 metric tons were produced valued at £14,175; in 1909, 142 metric tons, valued at £22,000.

*United Kingdom.*—The total amount of quicksilver imported into the United Kingdom in 1911 was 3,491,016 lb., as compared with 3,344,669 lb. in 1910. The principal importers were Spain with 2,689,575 lb. in 1911; Italy, 488,125 lb.; Austria-Hungary, 115,326 lb.; and Mexico, 118,261 lb. The total exports of quicksilver were 2,357,916 lb. in 1911, and 1,856,160 lb. in 1910. France, Russia, Germany, and China and the United States receive the largest consignments in the order named.

The quicksilver business in 1912 was characterized by very unsteady prices. The imports into London reached the record figure of 47,261 flasks, as compared with 46,547 flasks in 1911, and 44,595 flasks in 1910. The exports totaled 32,240 flasks, as against 31,438 flasks, and 24,748 flasks in the two preceding years. The consumption in England in recent years is estimated at 14,000 flasks. The following table shows imports and exports for the United Kingdom.

| | Imports. | Exports. | Price. | |
|---|---|---|---|---|
| | Flasks. | Flasks. | Highest. | Lowest. |
| | | | £ s d | £ s d |
| 1912 | 47,261 | 32,240 | 8 12 0 | 7 8 5 |
| 1911 | 46,547 | 31,438 | 10 0 0 | 7 10 0 |
| 1910 | 44,595 | 24,748 | 9 15 0 | 7 9 0 |
| 1909 | 43,163 | 22,050 | 9 17 6 | 7 19 0 |
| 1907 | 39,448 | 29,465 | 8 5 0 | 6 15 0 |
| 1905 | 34,034 | 21,330 | 7 15 0 | 7 1 0 |

QUICKSILVER PRODUCTION OF THE WORLD.
(Metric tons.)

| Year. | Austria. | Hungary. | Italy. | Mexico. | Russia. | Spain. | United States. | Total. |
|---|---|---|---|---|---|---|---|---|
| ..... | 491 | 7 | 173 | 353 | 362 | 1,691 | 1,058 | 4,135 |
| ..... | 536 | 27 | 205 | 324 | 360 | 1,357 | 993 | 3,802 |
| ..... | 510 | 32 | 260 | 124 | 304 | 1,095 | 983 | 3,308 |
| ..... | 525 | 33 | 278 | 128 | 368 | 754 | 1,031 | 3,117 |
| ..... | 511 | 45 | 259 | 191 | 416 | 1,425 | 1,208 | 4,055 |
| ..... | 523 | 44 | 314 | 188 | 362 | 968 | 1,288 | 3,687 |
| ..... | 536 | 45 | 357 | (e)190 | 332 | 1,130 | 1,192 | 3,782 |
| ..... | 519 | 36 | 370 | (e)190 | 318 | 853 | 1,045 | 3,331 |
| ..... | 526 | 50 | 418 | (e)200 | 210 | 1,568 | 963 | 3,935 |
| ..... | 527 | 40 | 434 | (e)200 | 130 | 1,212 | 712 | 3,255 |
| ..... | 594 | 78 | 684 | (e)200 | 147 | 1,068 | 685 | 3,358 |
| ..... | 637 | 80 | 771 | (e)200 | 7 | 1,393 | 713 | 3,801 |
| ..... | 603 | 90 | 894 | (e)250 | (e)20 | 1,114 | 763 | 3,734 |
| ..... | 704 | 80 | 955 | 95 | (e)20 | 1,486 | 732 | 4,072 |

)t reported. (e) Estimated.

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# RADIUM

Progress in determining the radium contents of the earth's crust has not yet led to definite results. Geological surveys, however, are more and more interested in the problem. The radium content of sedimentary rocks has been determined by Fletcher.[1]
He gives the following table:

| | |
|---|---|
| Coarse detrital sediments | 1.5 |
| Metamorphosed coarse detrital sediments | 1.5 |
| Fine detrital argillaceous sediments | 1.3 |
| Fine detrital schistose sediments | 1.1 |
| Calcareous sediments | 0.8 |

The weights of radium are expressed in parts in one million million. Radium in Alabama coals has been carefully determined by Stewart J. Lloyd and John Cunningham,[2] on representative samples of seams and which were collected by the Alabama Geological Survey. So far as is known no radium analysis of coal has been published. The following table shows the results:

| Mine. | Per cent. of Ash. | Ra per Gram Coal. | Ra per Gram Ash. |
|---|---|---|---|
| Wadsworth Red Ash | 4.3 | 0.0475 | 1.10 |
| Mary Lee | 16.13 | 0.34 | 2.19 |
| Pratt No. 5 | 4.94 | 0.37 | 7.05 |
| Blocton | 6.52 | 0.27 | 4.39 |
| Coalmont | 8.9 | 0.086 | 0.95 |
| Pratt No. 3 | 6.21 | 0.088 | 1.41 |
| Galloway | 10.67 | 0.34 | 2.95 |
| Corona | 9.56 | 0.054 | 0.57 |
| Conners-Weyman | 6.89 | 0.0475 | 0.69 |
| Little Cahaba | 6.57 | 0.028 | 0.51 |
| "Lignite" | 11.36 | 0.15 | 1.34 |
| | Average, | 0.166 | 2.15 |

In these determinations Joachimsthal pitchblende containing 46.2 per cent. uranium, is used as a standard, one part U being assumed equal to 3.4 ten millionths parts radium. The radium in the coal varies considerably. It does not depend on the amounts of sulphur, of fixed carbon or of volatile constituents. According to the recent theories, the slow disintegration of an atom of uranium gives an atom of helium and an atom of ionium, and the latter, in turn, an atom of helium and one of

[1] *Phil. Mag.*, XXIII, 279 (1912).
[2] University of Alabama.

radium, calculating by Boltwood's coefficient, there should be 0.1 grm. of $RaBr_2.2H_2O$ per 30 kg. of $U_3O_8$.

Radioactivity of springs was examined by the Imperial Russian technical society. The most radioactive ones are said to be the hot sulphur wells in Tiflis, Caucasus. The presence of uranium or thorium minerals in rocks of the country could not be confirmed.

Researches under direction of the Saxon Ministry of Finance, continue near Oberschlemma, Saxony. One source of radioactive water furnished 330 liters per day, the radioactivity being 4015 units.

The only radium ores obtained in the United States are pitchblende or uraninite and carnotite; the former is the oxide of uranium, the latter a mixture of uranium and vanadium salts. (See Uranium and Vanadium.)

Radium is not extracted from domestic ores in the United States. It is claimed, however, that much of the world's production now comes from such ores which are treated in Europe. Attempts to separate radium have been made in the United States by two companies, but it was determined that the chemical processes are perfected in existing laboratories of Europe where they can be carried out commercially. This applies also to the separation of vanadium and uranium in these American ores. Much ore is, therefore, being accumulated until a process is perfected in the United States. Uranium concentrates are also shipped to Europe. The value of imports of radium compounds in 1912 into the United States was $18,283.

The carnotite produced in the United States in 1912 contained 26 tons $U_3O_8$;[1] this would yield 11 grm. $RaBr_2$ valued at least $500,000.

The use of other uranium minerals for the extraction of radium is not commercially feasible as in most of them the percentage of uranium is very small. The minerals and prominent localities are enumerated in MINERAL INDUSTRY, Vol. XIX, p. 600.

*Austria.*—The output of St. Joachmisthal in 1912 was estimated at 5 grm. of radium salts, the works being at full capacity. In 1911 the production of radium chloride was 2.647 grm. valued at $214,928.

The average $U_3O_8$ contents of the pitchblende for 20 years was 55 per cent. The production of ore has, however, decreased. The high production of 3.8 grm. of salts was reached only by the accumulation of uranium material from the manufacturers of uranium colors. As these are a by-product the production of radium depends upon their market, which is limited. The uranium salts produced were 8.4 tons in 1908, 10.2 tons in 1909, 10.3 tons in 1910, 6.8 tons in 1911. As the radium salts are not actually consumed and a loaning system has arisen, the world's stock of these salts increases.

[1] Mineral Resources, *U. S. Geol. Surv.*

At the Radium Institute, the treatment of 10 tons of the complex ore requires 5 1/2 tons of chemicals and 55 tons of water, and more than 1000 crystallizations, each taking from two hours to two days.

*South Australia.*—The Radium Hill Company, in South Australia, the pioneer in exportation of the Olary district, is successfully producing radium bromide. The ore is concentrated in a magnetic separator plant at the mine, and the concentrates forwarded to Woolwich on the Paramatta River, near Sydney, the works treating about 10 tons per week. One hundred and twenty tons of concentrates have been smelted, of which 95 tons have been treated for about 350 mg. of radium, which is equivalent to an extraction of 3 2/3 mg. per ton of concentrate. The company proposed to utilize the by-products.

The South Australia Radium Proprietary has a lease on property northeast of the above. Four shafts have been sunk, and much development work done. Thirty tons of ore have been forwarded to Europe for treatment.

The Rare Metals Proprietary, working three miles northeast of the Radium Hill, has mined about 7 tons of vein matter, and done considerable prospecting work. Analyses are satisfactory. The Mount Painter property of the Radium Extraction Company of South Australia has not been working. The ore which was shipped, about 10 tons all told, was estimated to contain 2 per cent. of $U_3O_8$. The mining of radium ores in South Australia will be definitely decided upon during 1913.

*Other Countries.*—The company near Stockholm[1] is about to use a new process for extracting radium from the ores of Scandinavia (fergusonite) and a works is proposed to be established by Mr. Laudin, chemist.

The formation of La Société l'Industrielle du Radium (capital, £2,000,000) to acquire the South Terras mine, near Grampound Road in Cornwall, was announced. The ore is said to run 6 to 7 mg. per ton in radium, and on the lowest levels as high as 190 mg. Ra per ton of ore.

The company will build a works at Coupières, department of Seine-et-Oise, to treat 500 to 600 tons of ore per month. The French directors are: Prof. Jacques Danne, of the radium laboratory of Gif (Seine-et-Oise); Dr. J. Laboure, of Amiens; Dr. E. Guyenot, of Aux-les-Bains, and Dr. Paul Giraud, of Chantilly.

## Technology

Sidney Radcliff, of Bairnsdale, Victoria, Australia, has patented (U. S. pat. 1049145) a process for the recovery of: (1) Radium as mixed

[1] *Echo des Mines*, April 10, 1913.

sulphate of barium and radium; (2) uranium, as oxide or uranate; (3) acid earths, such as tantalum, niobium, or titanium, as oxides; (4) the rare earths, cerium, lanthanum, didymium, etc., as oxides.

The crushed ore or concentrate, crushed to 30- or 40-mesh, is fused in a reverberatory with 2 1/2 times its weight of acid sodium sulphate, and while fluid, sodium chloride, 10 to 15 per cent. the weight of the ore, is added.

The fused product is tapped out, cooled, crushed and agitated with warm water. This causes the uranium, iron, aluminum, rare earths and part of the niobium, titanium and tantalum (acid earths) to go into solution. The radium, as sulphate, remains in suspension with sulphates of lime, lead and barium, and fine gangue.

*Radium from Autunite.*—The possibility of using phosphatic uranium micas and copper autunite as a source of radium is discussed by F. Glaser.[1] The specimens of Portuguese rocks containing autunite examined by the author have yielded from 0.1 to 4.5 per cent. of $U_3O_8$. For separation of the uranium the autunite is extracted with hydrochloric acid, and the extract neutralized with lime, which precipitates uranium, copper, radium and iron. Another method of decomposing the mineral is to boil with sodium carbonate, when the uranium is dissolved and the radium retained. This process is slow for calcium autunite, but more rapid for copper autunite, from which, however, some copper goes into solution with the uranium. It is found that appreciable quantities of sulphuric acid in the commercial hydrochloric acid used for extraction do not greatly decrease the amount of radium extracted, in spite of the very low solubility of radium sulphate. Presumably this solubility is increased by the ferric salts, etc., which are also present.

The treatment of cancer by radium, while encouraging in that certain cases were cured,[2] is still in an experimental stage. Symptoms are alleviated in some cases. Rodent ulcers are the most amenable to radium treatment.

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[1] *Chem Zeit.*, p. 1166, 1912, abstr. *Journ. Soc. Chem. Ind.*, p. 1030, 1912.
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# SALT

In the United States the production of salt in 1912 is estimated at 33,324,808 bbl. as compared with 31,183,968 bbl. in 1911.[1] This figure includes Hawaii and Porto Rico. The chief producers as heretofore are Michigan, New York, Ohio and Louisiana. New York led the production in the last 3 years and surpassed that of Michigan in the last 2 years.

In 1911 the output of all grades of salt increased uniformly, excepting rock salt. This class had a largely increased production in 1910 over 1909. The following table shows the production by grades for 1910 and 1911:

| | 1910 | 1911. | 1912. |
|---|---|---|---|
| Table and dairy | 3,514,748 | 3,773,798 | 3,961,450 bbl. |
| Common fine | 6,153,296 | 6,267,350 | 6,021,052 bbl. |
| Common coarse | 2,602,737 | 2,970,492 | 2,753,375 bbl. |
| Packers | 327,304 | 408,928 | 751,551 bbl. |
| Solar | 1,223,371 | 1,343,046 | 1,105,935 bbl. |
| Rock | 6,965,938 | 6,232,210 | 7,091,759 bbl. |
| Other grades | 129,036 | 160,233 | 231,063 bbl. |
| Brine | 9,389,226 | 10,027,411 | 11,408,623 bbl. |
| Totals | 30,305,656 | 31,183,968 | 33,324,808 bbl. |

The production of salt in the United States is shown in the following table:

PRODUCTION OF SALT IN THE UNITED STATES. (*a*)
(In barrels of 280 lb.)

| Year. | California. | Illinois. | Kansas. | Louisiana. | Michigan. (*c*) | Nevada. | New York. (*c*) | Ohio, W. Virginia and Pa. (*b*) | Utah. | Other States. | Total Barrels. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1901 | 601,659 | 99,700 | 2,087,791 | 451,430 | 7,729,641 | 13,781 | 7,286,320 | 1,385,257 | 334,484 | 569,092 | 20,869,342 |
| 1902 | 682,680 | 90,009 | 2,158,486 | 399,163 | 8,131,781 | 14,829 | 8,523,389 | 2,318,579 | 417,501 | 1,112,824 | 20,566,661 |
| 1903 | 629,701 | (*d*) | 1,555,934 | 568,936 | 4,297,542 | (*d*) | 8,170,648 | 3,043,135 | 212,995 | 489,238 | 23,849,221 |
| 1904 | 821,557 | (*d*) | 2,161,819 | 1,095,850 | 5,425,904 | (*d*) | 8,600,656 | 3,030,829 | 253,829 | 639,558 | 18,968,089 |
| 1905 | 664,099 | (*d*) | 2,098,585 | 1,055,186 | 9,492,173 | (*d*) | 8,359,121 | 2,728,709 | 177,342 | 1,390,907 | 22,030,002 |
| 1906 | 806,788 | (*d*) | 2,198,837 | 1,179,528 | 9,936,802 | 11,249 | 8,978,630 | 3,436,840 | 262,212 | 1,361,494 | 25,966,122 |
| 1907 | 626,693 | (*d*) | 2,667,459 | 1,157,621 | 10,786,630 | 6,459 | 9,657,543 | 4,007,390 | 345,557 | 464,143 | 28,207,743 |
| 1908 | 899,028 | (*d*) | 2,588,814 | 947,129 | 10,194,279 | 9,714 | 9,005,311 | 3,572,635 | 242,678 | 1,291,042 | 29,719,493 |
| 1909 | 886,564 | (*d*) | 2,769,849 | (*d*) | 9,966,744 | 16,107 | 9,880,618 | 3,835,267 | 246,935 | 2,505,562 | 28,754,630 |
| 1910 | 937,514 | (*d*) | 2,811,448 | 1,372,248 | 9,452,022 | 17,535 | 10,270,272 | 3,829,475 | 249,850 | 1,365,292 | 30,305,656 |
| 1911 | 1,086,163 | (*d*) | 2,159,859 | (*d*) | 10,320,074 | 12,856 | 10,082,656 | 4,485,886 | 272,420 | 2,764,454 | 31,183,968 |
| 1912 | 1,090,000 | (*d*) | 2,573,626 | (*d*) | 10,946,739 | 12,536 | 10,502,214 | 5,408,300 | 283,293 | 2,508,100 | 33,324,808 |

(*a*) Statistics of the U. S. Geological Survey except for New York since 1905, which are from reports of the State Geologist. (*b*) The production of Pennsylvania since 1905 is included in "Other States." (*c*) Includes brine used in manufacture of alkali. (*d*) Included in "Other States."

[1] *U. S. Geol. Surv.*

CONSUMPTION OF SALT IN THE UNITED STATES.
(In tons of 2000 lb.)

| Year. | Production. | | Imports. | | Exports. | | Consumption. | |
|---|---|---|---|---|---|---|---|---|
| | Amount. | Value. | Amount. | Value. | Amount. | Value. | Amount. | Value. |
| 1898..... | 2,465,769 | $6,212,554 | 185,530 | $588,653 | 8,640 | $ 63,624 | 2,642,659 | $6,737,583 |
| 1899..... | 2,759,206 | 6,867,467 | 189,051 | 579,682 | 12,600 | 86,465 | 2,935,657 | 7,360,684 |
| 1900..... | 2,921,708 | 6,944,603 | 199,909 | 634,307 | 7,511 | 65,410 | 3,114,106 | 7,513,500 |
| 1901..... | 2,879,332 | 6,617,449 | 201,733 | 676,324 | 9,433 | 86,414 | 3,071,632 | 7,207,359 |
| 1902..... | 3,338,892 | 5,668,636 | 184,764 | 647,554 | 5,094 | 55,432 | 3,518,562 | 6,260,758 |
| 1903..... | 2,655,532 | 5,286,988 | 165,981 | 495,948 | 12,750 | 95,570 | 2,808,763 | 5,687,366 |
| 1904..... | 3,084,200 | 6,021,222 | 166,140 | 467,754 | 13,964 | 113,625 | 3,236,376 | 6,375,351 |
| 1905..... | 3,635,257 | 6,095,922 | 161,159 | 492,189 | 34,238 | 239,223 | 3,762,178 | 6,348,888 |
| 1906..... | 3,944,133 | 6,658,350 | 170,505 | 502,583 | 33,988 | 274,627 | 4,080,650 | 6,886,306 |
| 1907..... | 4,160,729 | 7,439,551 | 153,435 | 452,227 | 30,802 | 232,895 | 4,283,362 | 7,658,883 |
| 1908..... | 4,024,345 | 7,486,894 | 156,609 | 440.484 | 26,627 | 202,338 | 4,154,327 | 7,725,040 |
| 1909..... | 4,215,070 | 8,343,831 | 158,487 | 447,983 | 40,158 | 269,273 | 4,333,397 | 8,522,541 |
| 1910..... | 4,242,792 | 7,900,344 | 142,549 | 388,015 | 49,013 | 320,926 | ..... | ..... |
| 1911..... | 4,365,756 | 8,345,692 | 137,759 | 378,083 | 48,873 | 335,285 | ..... | ..... |
| 1912..... | 4,665,473 | 9,402,772 | 136,391 | 361,664 | 62,410 | 418,525 | ..... | ..... |

*New York* (By D. H. Newland).—The occurrence of rock salt is widespread in the central and western counties, south of the Salina outcrop, but exploration through mine shafts or wells is restricted to a few places that possess natural advantages for conducting these operations and for marketing the product. Six counties contribute to the output, with a total of about 30 individual mines and evaporating works.

Few changes have taken place recently in the industry and it is hardly to be expected that any notable developments will occur in the near future. The productive capacity of the local plants long since reached or passed the point of equilibrium with the market requirements. This condition has caused keen competition and brought about the extinction of some of the smaller and less favorably situated enterprises. The industry, as a whole, however, seems to be on a firm basis and except for some uncertainty as to the results of the new tariff which proposes to remove the duty on foreign salt, the outlook for the immediate future is more encouraging than it has been in several years.

Reports from all of the companies operating last year showed a production of 10,502,214 bbl. of 280 lb., the largest total ever returned for a single year, the next largest having been in 1910 (10,270,273 bbl.). The product last year was equivalent to 1,470,309 short tons, against 1,411,572 short tons for 1910.

The value of the salt production as fixed by the figures reported by the companies was $2,597,260, exclusive of the cost of package and freight to market. From this, an average of 24.7 cents a barrel is obtained for the whole amount. The prices received for evaporated salt were generally higher than in the preceding year and in fact in any other year since 1907. Under the highly competitive conditions that have existed in the local

narkets as well as in those of other states where the New York producers ıave a foothold, prices have slumped steadily during the previous few ears. In 1911, the average value was only 21.7 cents, whereas it was 22 ents in 1910, 23.3 cents in 1909, 23.7 cents in 1908 and 25 cents in 1907.

It is to be noted that the average values as given are for the entire ımount of salt taken from the mines and wells, and that a certain and not nconsiderable part of this amount represents the salt contents of brine vhich is not evaporated, but converted directly into alkali products. On this part of the output, a very low valuation, representing practically he mere cost of pumping, is placed. The production of this brine is confined to a single company, the Solvay Process Co., which has a number of wells in the town of Tully, Onondaga County, whence the brine is carried by pipe-line to the alkali works near Syracuse.

The accompanying tables give the statistics of the salt production for recent years. For the years 1911 and 1912 the output is given according o grades, so far as the classification could be made without revealing the ndividual figures. The grades depend upon methods of manufacture and ourposes for which the salt is used. Rock salt and salt in brine consumed oy the alkali industry appear in the last item of the detailed tables which ılso includes small quantities of evaporated salt not specially classified n the returns. The evaporated salt is chiefly marketed under the grades of common fine, table and dairy, common coarse, common solar, and oackers salt. Table and dairy salt includes the finest grades of artificially evaporated specially prepared for the table and for butter and cheese naking; it brings the highest market price. Under common fine are isted the other grades of fine, artificially evaporated salt that are not specially prepared. Common coarse represents the coarser product rom artificial evaporation. Coarse solar salt is made by evaporation of orine in shallow pans exposed to the sun's heat. This process is employed

PRODUCTION OF SALT BY GRADES IN NEW YORK STATE.

| Grade. | 1911. | | | 1912. | | |
|---|---|---|---|---|---|---|
| | Barrels. | Value. | Value per Barrel. | Barrels. | Value. | Value per Barrel. |
| ommon fine[1] | 1,143,886 | $328,127 | $0.29 | 1,408,543 | $519,844 | $0.37 |
| ommon coarse | 285,407 | 96,968 | 0.34 | 204,136 | 82,880 | 0.41 |
| able and dairy | 1,312,000 | 629,581 | 0.48 | 1,353,643 | 819,103 | 0.61 |
| oarse solar | 434,414 | 131,247 | 0.30 | 296,814 | 103,886 | 0.35 |
| ackers | 40,721 | 11,402 | 0.28 | 72,771 | 30,564 | 0.42 |
| ther grades[2] | 6,866,228 | 994,160 | 0.14 | 7,166,307 | 1,040,983 | 0.15 |
| Total | 10,082,656 | $2,191,485 | $0.217 | 10,502,214 | $2,597,260 | $0.247 |

[1] Common fine includes a small quantity of common coarse.
[2] Include rock salt, salt in brine used for soda manufacture, and small amounts of brine salt for which ıe uses were not specified in the returns.

only by the manufacturers in Syracuse and vicinity, and can be carried on, of course, only in the summer months. Packers salt includes the product sold to meat packers and fish salters.

The output in 1912 was contributed by 30 mines and works distributed among six counties of the State. Livingston County was represented by 3, of which 2 were rock salt mines, the only ones now active.

PRODUCTION OF SALT IN NEW YORK SINCE 1887.

| Year. | Barrels. | Value. | Year. | Barrels | Value. |
|---|---|---|---|---|---|
| 1887 | 2,353,560 | $936,894 | 1900 | 7,897,071 | 2,171,418 |
| 1888 | 2,318,483 | 1,130,409 | 1901 | 7,286,320 | 2,089,834 |
| 1889 | 2,273,007 | 1,136,503 | 1902 | 8,523,389 | 1,938,539 |
| 1890 | 2,532,036 | 1,266,018 | 1903 | 8,170,648 | 2,007,807 |
| 1891 | 2,839,544 | 1,340,036 | 1904 | 8,724,768 | 2,102,748 |
| 1892 | 3,472,073 | 1,662,816 | 1905 | 8,575,649 | 2,303,067 |
| 1893 | 5,662,074 | 1,870,084 | 1906 | 9,013,993 | 2,131,650 |
| 1894 | 6,270,588 | 1,999,146 | 1907 | 9,657,543 | 2,449,178 |
| 1895 | 6,832,331 | 1,943,398 | 1908 | 9,005,311 | 2,136,736 |
| 1896 | 6,069,040 | 1,896,681 | 1909 | 9,880,618 | 2,298,652 |
| 1897 | 6,805,854 | 1,948,759 | 1910 | 10,270,273 | 2,258,292 |
| 1898 | 6,791,798 | 2,369,323 | 1911 | 10,082,656 | 2,191,485 |
| 1899 | 7,489,105 | 2,540,426 | 1912 | 10,502,214 | 2,597,260 |

The large number of producers (20) in Onondaga County is incident to the solar salt industry which is carried on extensively around Syracuse. The brine used by the solar evaporating works or salt yards is stored in glacial gravels and is pumped and distributed by central plants. The principal supply comes from the old Onondaga Salt Springs Reservation that was sold by the Indians to the State in 1788. The manufacture of salt was placed under State control in 1797, from which time complete records of the industry are available. At one time artificial evaporation was extensively practised, but this has been given up almost entirely in recent years with the increased competition from other districts. The solar salt is sold through the agency of the Onondaga Coarse Salt Association.

With the exception of the salt made at Syracuse the entire production is obtained from the deposits of rock salt which are found in the Salina formation, a succession of shales and limestones with intercalated beds of gypsum and rock salt. The Salina strata outcrop is an east-west belt across the State from Albany County to the Niagara River and is represented by a smaller separate area in southeastern New York. Well tests indicate that the salt deposits are restricted to the western section of the main belt beginning in Madison County; east of there the strata diminish in thickness to such an extent as to preclude their existence. There are encountered only at a depth of 1,000 ft. or more where there has been sufficient cover to protect them against solution by ground waters. As the whole stratified series has a dip un-

iformly toward the south the mines and wells are all located on the southern side of the outcrop, which lies about on the line of the forty-third parallel. The dip averages 40 or 50 ft. to the mile. The most easterly point where rock salt has been found is at Morrisville, Madison County. Between that place and Lake Erie it has been shown to exist in almost all of the middle tier of counties.

The exploration of the rock salt beds dates from 1878 when a well bored for oil near Wyoming, Wyoming County, encountered 70 ft. of salt at 1270 ft. from the surface. Discoveries were subsequently made at Warsaw, Leroy, Rock Glen, Batavia and numerous places in Livingston, Wyoming and Genesee counties. Practically the whole valley of Oatka Creek, from Leroy to Bliss and the Genesee valley south of Monroe County has been found to be salt bearing. The region is now the most productive in the State. Livingston County has the largest annual output which is contributed by the two rock salt mines at Retsof and Cuylerville, owned respectively by the Retsof Mining Co. and the Sterling Salt Co., and by the evaporating plant of the Genesee Salt Co., at Piffard. The other companies now active in this section include the Leroy Salt Co., of Leroy; the Rock Glen Salt Co., of Rock Glen; and the Worcester Salt Co., of Silver Springs.

In Schuyler County salt is obtained around Watkins. The Glen Salt Co. sank the first well there in 1893 and encountered a deposit at 1846 ft. depth. The plant is now operated by the International Salt Co. The Watkins Salt Co. also has works at this place.

A well drilled at Ithaca, Tompkins County, in 1885 passed through seven beds of salt aggregating 248 ft. in thickness at depths below 2244 ft. from the surface. The discovery was followed by active developments at Ludlowville in 1891 by the Cayuga Lake Salt Co., and at Ithaca in 1895 by the Ithaca Salt Co. The plants were taken over in 1899 by the National Salt Co., which was merged in 1905 into the International Salt Co. The Remington Salt Co. later erected a plant at Ithaca which is now in operation obtaining its salt from three wells at a depth of about 2100 ft.

The Solvay Process Co. derives its supply of brine from a number of wells located in the town of Tully, 20 miles south of Syracuse. The brine is carried in pipe-line to the works at Solvay.

In Erie County rock salt has been found at Eden Valley, Springville, Perry and Gowanda, but there is no output at present in that county. Among the localities where discoveries have been made may be mentioned Vincent and Naples, Ontario County; Dundee, Yates County; Seneca Falls, Seneca County; and Aurora, Cayuga County. None of these deposits are worked. A well put down in 1909 in the town of Burns, Alleghany

County, is reported to have passed through 75 ft. of clean unbroken salt at 3050 ft. depth.

*Michigan.*—The private enterprises began with the year 1859. The development of the industry was very rapid until, in 1876, the State became the leading producer in the United States. Michigan was still the leading producer in 1893 when New York resumed the first place. Since that year the first place was held by either Michigan or New York. The statistics of the United States Geological Survey, gathered directly from producers, have been complete since 1893. They included, however, considerable brine used in the manufacture of soda ash, etc. It may be noted that the tariff act of 1894, which placed salt on the free list, corresponds with a low market of production in the State of Michigan. The quick increase after this year, both in Michigan and the United States, corresponds to the development of the soda-ash industry. The largest amount of salt produced in Michigan, as reported by the United States Geological Survey, was in the calendar year 1907. The year 1911, when the output became 10,320,074 bbl. valued $2,633,155, was the second best production.

Rock salt is mined by the Detroit Salt Co., at Detroit. The salt occurs in the Monroe formation, or Salina, being the same as that in New York State. It is supposed that the brines obtained from rock salt of the lower peninsula, in the western part, is also of this horizon. Deposits of other companies besides the Detroit, making salt from artificial brine, are in the same geological formation. The natural brines, which yielded considerable by-product in the way of calcium chloride and bromine, occur higher up geologically (Carboniferous versus Silurian) and this formation of sandstone occurs about 750 to 1000 ft. below the surface along the Saginaw.

*Ohio.*—The production of Ohio ranks third of the States, and in 1911 was 4,302,507 bbl. (602,351 tons), valued at $1,100,453, and in 1912 5,269,179 bbl. (737,685 tons), valued $1,364,136. The production in 1910 was reported by the United States Geological Survey as 3,673,850 bbl. valued at $951,963. The principal district is the southeastern, with Pomeroy as the center. The formation into which the wells are drilled is near the top of the "Conemaugh" (formerly Lower Barren Coal Measures). The production of the wells has been maintained by increasing their depths, until now both in Ohio and West Virginia brine is being pumped from depths of 1100 to 1350 ft. The relatively large quantities of bromides in these brines is probably due to the salt-bearing rocks being deposited very near the shore line and being part of a land-locked sea. The other district producing salt in Ohio, namely, the northeastern, procures its brines from the Monroe formation of the Silurian.

*Kansas.*—A large body of rock salt underlies the central part of the State, but its boundary is not exactly known. It extends southward into Oklahoma. The salt-bearing formation consists of layers of salt, shale, limestone and gypsum, the salt being often 20 ft. in thickness. The total thickness of the formation is about 400 ft. The evaporated salt industry has its center near Hutchinson. The description of the development of this industry and also of the rock salt industry, is given by C. M. Young.[1]

*Louisiana.*—The state leads in rock salt production. Salt is mined at Weeks and Avery in Iberia Parish. The mining, etc., have been described by Paul Wooten.[2] Further details as to location, etc., are given by G. D. Harris.[3]

*Virginia.*—Salt and gypsum occur in the vicinity of Saltville, where more than fifty salt wells have been drilled, of which twenty-five are in operation.

The deposits near Saltville, Va., which have been worked from an early date, are described by Geo. W. Stose.[4]

The analysis of the rock salt is stated[5] as 99.084 NaCl, $CaSO_4$ .446 and $Al_2O_3$ $SiO_2$ and Fe .47 per cent. The industry, since 1895 in the control of the Mathieson Alkali Works has been developed for alkalis.

The wells average 1000 ft. in depth, but one is 2,280 ft., and many are shallow.

In converting salt to sodium products, limestone of the requisite purity is obtained at Marion, Va., 25 miles distant from the works on the Holston River. It is said that 600 tons daily are consumed for the carbonic acid required in making sodium bicarbonate ($NaCO_3$) by the ammonia process; much soda ash is also manufactured the bicarbonate being calcined for this purpose. Acres are covered with lime mud, 200 tons of which are wasted daily, but no method for utilizing this material has been perfected.

*West Virginia.*—In 1912 the output reported by the United States Geological Survey, was 139,121 bbl. valued at $66,023. The brines contained both bromine and calcium chloride. The geology has been worked out,[6] and is similar to that of Pomeroy, Ohio. Brines occur on the Kanawha River, near Malden. The records of a gas well 3 miles north of this place are reported by I. C. White.[7] The sandstone from which these brines are derived, and known to the oil-men as "Salt-Sand," belongs to the Pottsville formation near the base of the coal measures.

[1] *Eng. and Min. Journ.*, Sept. 18, 1909; pp. 558–561; *Eng. and Min. World*, June 17, 1911, pp. 1223–225; MINERAL INDUSTRY, Vol. XIX, p. 602.
[2] *Min. and Eng. Wld.*, Feb. 17, 1912; *Abstract* MINERAL INDUSTRY, Vol. XX, p. 663.
[3] *Bull.* No. 7, *Louisiana Geol. Surv.*, p. 5, 1908.
[4] *Bull.* 530, *U. S. Geol. Surv.*, 1913, p. 233, 241.
[5] T. L. Watson, *Min. Resources of Virginia*, 1907, p. 213.
[6] J. A. Bownocker, *Bull.* No. 8, Ohio Geol. Surv.
[7] *West Virginia Geological Surv.*, Vol. I, p. 272.

*Pennsylvania.*—The brines are derived from the same formation, namely, the Pottsville, approximately at a depth of 1,400 ft.

*Texas.*—Texas produced 373,064 bbl. of salt valued at $290,328 in 1912. The principal producers were Anderson and Van Zandt Counties. This state although not producing as it did maintains an important production. The figures for previous years are: 1909, 409,315 bbl.; 1910, 382,164 bbl.; 1911, 385,200 bbl., the latter valued $299.537.

*Utah.*—Utah produced 272,420 bbl. of salt in 1911, valued at $171,268, and 283,293 bbl. valued $154,734 in 1912. The value of the product declined in the last year. A description of the industry on the Great Salt Lake is given by Percy E. Barbour.[1]

*California.*—California supplies salt, some of which is exported, to the extent of nearly 1,000,000 bbl. per year. Most of this is obtained by solar evaporation, although some 80,000 bbl. are mined by one company in San Bernardino County. The industry is chiefly in Los Angeles County. The price of salt on the coast is high, compared with other parts of the United States. In 1909, the average was 63 cents and in 1910, 55 cents per barrel of 280 lb. The output in 1911 was 173,332 tons (2000 lb.) valued $324,255 and in 1910, 174,920 tons valued $395,417. In 1912 the value per bbl. was 57 cents.

*Calcium Chloride.*—In 1911, the production of bromine was 651,541 lb., and of calcium chloride, 14,606 tons, according to the U. S. Geological Survey. The manufacture of bromine is conducted by concentrating the bittern to about 41 to 43° Bé., after which it goes to sandstone stills, is mixed with sulphuric acid and potassium chlorate and steam blown into the mixture, heating it to a temperature of about 180° F. The bromine passes off through lead pipes to a condenser. The residual liquor is neutralized with lime, and heated to a thick, sirupy liquid, which is run into drums, holding 600 to 700 lb., where it cools, and forms a solid mass of calcium chloride.

## Foreign Countries

The foreign salt market and industry for the years 1910–1911 are reviewed in the Special Consular Report No. 52, issued by the Department of Commerce and Labor, 1912. The following notes in addition may be of interest.

*Arabia.*—The production from ocean brine at Aden is estimated at 105,000 tons. Most of this is exported to India.

*Australia.*—A good season in South Australia ended with June 30, 1912, and it is estimated that 63,000 tons have been scraped.

[1] *Eng. and Min. Journ.*, July 8, 1911, p. 74; Mineral Industry, Vol. XX, p. 663.

*Belgium.*—In Belgium forty salt works refined imported salt. The yearly output is about 30,000 tons, but Belgium imported, in 1910, 64,000 tons of refined salt, chiefly from France, Great Britain and Germany. The crude salt imported amounted to 142,000 tons of which the bulk came from France and Germany, and 10,000 tons from Tunis.

*Canada.*—Practically all the salt comes from Ontario, in the southwestern peninsula. The 1912 yield was 88,689 tons valued at $430,835.

*France.*—The production of salt in recent years has been as follows:

| Metric Tons. | 1911. | 1910. | 1909. |
|---|---|---|---|
| Rock salt | 122,000 | 115,000 | 111,000 |
| Brine | 267,000 | 254,000 | 226,000 |
| Used in soda works | 445,000 | 397,000 | 372,000 |
| Sea salt | 504,100 | 285,000 | 404,000 |
| Totals | 1,339,000 | 1,051,427 | 1,113,000 |

The value of the sea salt in 1911 at the works was 7,636,321 francs. The value of other salt was 11,190,278 francs. The production of brine in Algeria was 20,431 tons valued at 550,125 francs, in 1911. The production of salt in Tunis was 63,700 tons in 1911, as compared with 199,700 tons in 1910. The average price of salt was 3.36 francs per ton.

*Germany.*—In Brunswick the sales of the salt manufactured by the three companies are subject to the agreement entered into with the Deutsche Salinenvereinigung. The quantities of salt sold are reported in 1912 as follows: Total sales in metric tons—Schoeningen, 22,643; Hedwigsburg, 15,336; Thiederhall, 1,840. The total salt consumed is estimated at 590,925 tons for 1912, as compared with 578,813 tons in 1911, 606,077 tons in 1910, and 574,018 tons in 1909. Small amounts of Portuguese and English salt are included in these figures. The salt produced in Bavaria in 1910 was 45,141 tons valued at 2,053,030 marks, and in 1911, 41,201 tons valued at 1,872,987 marks. The rock salt produced in Bavaria in 1911 amounted to 782 tons valued at 14,319 marks, and in 1910, 1192 tons, valued at 19,026 marks. A large district in Alsace-Lorraine contains nine salt works which produced in 1911 68,343 metric tons. The annual production of brine salt in Thuringia is about 2000 tons. The rock salt produced at the Royal salt mine in Erfurt is annually 16,000 tons.

*India.*—In 1911 a marked decrease in production took place. The production was 1,310,921 long tons, compared with 1,325,882 tons in

1911. In addition to this, a production of rock salt which increased slightly was 146,186 tons in 1911 and 140,637 tons in 1910.

*Japan.*—The Japan Salt Manufacturing Co. has five salt gardens, having an annual production of 133,000,000 lb.

The production in Japan, not including Taiwan, is as follows for fiscal years:

| | |
|---|---|
| 1911 | 567,715 metric tons |
| 1910 | 597,035 metric tons |
| 1909 | 622,829 metric tons |
| 1908 | 604,963 metric tons |
| 1907 | 564,787 metric tons |

*Mexico.*—Brines obtained at San Luis Potosi are worked under British management. The output is approximately 15,000 tons per year. The chief export of salt from Mexico is to Guatemala. In 1912 it amounted to 321,479 kg. valued 14,592 pesos.

*Netherlands.*—The salt used in the Netherlands is imported in the crude state, largely from Portugal, and is refined in thirty-three establishments. The first modern factory for evaporating saline solutions on the principle of double effect was built in the Netherlands. The annual consumption of salt appears to be about 43,000 tons, in addition to 60,000 tons of fine salt.

*Peru.*—The production of Peru was 17,594 tons in 1910, and 24,867 tons in 1911, of which latter 17,335 tons were used for domestic purposes.

*Roumania.*—The latest official[1] figures give the salt production and cost of extraction:

| Years. | Tons. | Cost. |
|---|---|---|
| 1905–6 | 115,681 | $2.85 per ton |
| 1906–7 | 124,400 | 2.35 per ton |
| 1907–8 | 129,287 | 2.97 per ton |
| 1908–9 | 122,978 | 3.55 per ton |
| 1909–10 | 148,918 | 3.80 per ton |

The salt is made from brines and about one-third is exported and two-thirds consumed in the country. The tax for home consumption is about $19 per ton and for export about $5.60 per ton.

*Russia.*—The salt industry which exists on the shores of the Black and Azof seas, and also north of the Caspian Sea, centers at Odessa. One syndicate formed at Eupatoria in former times became wealthy. A discovery of rock salt in the Backmut region destroyed this syndicate.

[1] *Anuarul Statistic.*

The salt dealers in this region are not able to compete with the rock salt from Poland and the brine of Western Russia. The Minister of Finance has collected statistics for nine provinces around the Baltic, which show that the consumption in 1910 was 222,385 tons of salt. The production of salt in Russia increased during the last 10 years from 12,000,000 to 119,000,000 poods per annum. The Backmut district (Province of the Yekaterinosla) produced in 1911 666,000 tons, and in 1910, 612,000 tons. The total rock salt consumption in South Russia is estimated at 720,000 tons. It is estimated that the capacity for production is over 1,000,000 tons.[1] The salt production of Russia is divided approximately as follows: Donetz basin 28 per cent.; Backmut 25 per cent.; Baskunchak and Crimea 22 per cent.; Perm, Orenburg 20 per cent. In 1909, 57 per cent. of the salt came from lakes, and 20 per cent. from brines.

*Spain.*—The salt exported from Spain in 1911 was 503,231 tons, and in 1912, 552,043 tons. 168 salt works operated in 1911. The production and importation in 1909 were as follows: Rock-salt mines, 26,696 metric tons; sea-salt, 800,702 tons; imports, 14,776 tons; the exports amounted to 558,721 tons. In 1911 the common salt produced was 654,767 tons.

*Turks Island.*—The total exports of salt in 1911 were 1,497,207 bushels, valued at $94,784. The United States took most of this salt.

*United Kingdom.*—The rock salt produced from mines in 1911 amounted to 200,620 tons. The amount of salt produced from brine in 1911 amounted to 1,882,068 tons. Cheshire and Staffordshire are the chief salt-producing counties. The quantity of salt exported during 1911 was 604,869 tons, a large part of which went to the British East Indies.

The large salt companies are: the Salt Union (capital £2,600,000); the International Salt Co. (capital £214,000); the Commercial Salt Company, Ltd. (capital £77,500). The Salt Union uses the vacuum process, and is said to make salt for a total cost of 8s. per ton. The International treats rock salt by the "Tee" system, and it is claimed to be making salt for a cost of 5s. 8d. per ton. The Commercial Salt Company controls the rights in the United Kingdom for the Hodgkinson process, and claims that the costs will be below 3s. 6d. per ton. The latter company has erected a plant, and has acquired brine land in Cheshire. These lands contain three layers of rock salt, and furnish a brine carrying 2 lb. 10 oz. of salt to the gallon. A new plant is being erected, having a capacity of 400 tons of salt per week. Details of the Hodgkinson process are not disclosed.

[1] *Dly. Consle. and Ted. Rpts.*, March 7, 1913, p. 1150.

PRODUCTION OF SALT IN FOREIGN COUNTRIES.
(In metric tons.)

| | 1902 | 1903 | 1904 | 1905 | 1906 | 1907 | 1908 | 1909 | 1910 | 1911 |
|---|---|---|---|---|---|---|---|---|---|---|
| Algeria | 27,263 | 26,329 | 18,563 | 27,000 | 22,615 | 20,400 | 25,215 | 17,817 | 21,470 | 20,400 |
| Austria | 310,807 | 359,014 | 369,877 | 343,375 | 378,912 | 395,053 | 388,133 | 359,801 | 345,629 | 342,732 |
| Canada | 57,203 | 56,671 | 62,411 | 41,170 | 69,291 | 73,858 | 76,219 | 76,286 | 76,310 | 83,105 |
| France | 863,927 | 967,531 | 1,153,754 | 1,130,000 | 1,335,410 | 1,226,000 | 1,099,856 | 1,113,000 | 1,051,427 | 1,339,000 |
| Germany | 1,583,458 | 1,693,935 | 1,701,654 | 1,177,557 | 1,870,212 | 1,950,689 | 1,997,635 | 2,018,607 | 2,093,184 | 2,032,483 |
| Greece | 25,200 | 26,000 | 27,000 | 25,201 | 25,167 | 26,966 | 23,988 | 29,448 | 25,978 | 59,940 |
| Hungary | 174,882 | 183,327 | 187,620 | 195,410 | 201,369 | 395,000 | (c) | 231,182 | 230,315 | 239,006 |
| India (d) | 1,056,899 | 908,911 | 1,188,900 | 1,212,600 | 1,176,324 | 1,120,453 | 1,390,153 | 1,275,688 | 1,720,194 | 1,495,687 |
| Italy | 458,497 | 488,506 | 464,326 | 437,699 | 496,872 | 505,000 | 513,070 | 464,469 | 503,237 | 521,453 |
| Japan | 620,820 | 657,489 | 701,965 | 483,506 | 484,000 | 636,168 | 659,202 | 696,049 | 696,474 | 567,715 |
| Russia | 1,847,019 | 1,658,938 | 1,908,275 | 1,844,678 | 1,730,934 | 1,873,171 | 1,879,717 | 2,255,233 | 2,047,980 | (c) |
| Spain | 426,434 | 427,394 | 543,674 | 493,451 | 541,978 | 605,895 | 822,677 | 800,703 | 678,057 | 654,767 |
| U. Kingdom | 1,924,273 | 1,917,184 | 1,921,899 | 1,920,149 | 1,996,593 | 2,016,510 | 1,873,555 | 1,851,999 | 2,083,543 | 2,116,115 |
| U. States | 2,409,174 | 2,408,646 | 2,797,461 | 3,297,285 | 3,578,061 | 3,773,781 | 3,742,726 | 3,823,068 | 3,849,035 | 3,159,800 |

(c) Statistics not yet published. (d) Does not include the untaxed output of certain native states.

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# SELENIUM AND TELLURIUM

By Donald M. Liddell

There appear to have been no new developments in the metallurgy of selenium and tellurium during the last year. It is understood that three copper refineries have equipped themselves with slimes-roasting furnaces to recover selenium more economically, but that the market is dead for that metal, and that there are several tons of it stored up now awaiting a purchaser. In spite of the difficulty which it is understood the northern refineries have had in marketing their goods, it is reported that 8000 lb. or more has gone to Hamburg through Baltimore, thus reducing American stocks.

Wassermann's and Ehrlich's experiments on the cure of mouse cancer by selenium compounds[1] do not appear to have reached any definite conclusion, and in fact, any collodial metal (especially copper) is understood to answer as well as does selenium.

The production of about 11,000 lb. of selenium per annum by the American copper refineries is mainly used in the production of red glass and red-enameled ware.[2] The dioxide does not give any color, but by reducing the selenium dioxide by arsenic trioxide, by carbon or by fusion in a reducing atmosphere, the red color is obtained. This, however, is apparently not due to metallic selenium, but to selenides, for when the glass is dissolved in hydro-fluosilicic acid, hydrogen selenide is evolved. In general it appears that soda-lime mixes are unsuitable for producing selenium red glass, as are also zinc, boric-acid, phosphoric-acid, stannic-oxide, or calcium-fluoride glasses. This means that the glass must be a potash glass, and preferably highly acid. A good mix was found to be that of Bohemian glass, 1.49 $K_2O$ : CaO : 9.8 $SiO_2$.

The statement is made in *Sprechsaal* that the production of 11,000 lb. is made by three firms. As there are five firms producing from time to time, the above production estimate is probably under the proper figure.[3]

The possibilities of production are discussed in Mineral Industry, Vol. XX, p. 665.

The use of selenium as a coloring matter or "stain" in glass dates from 1891,[4] when Welz patented the use of selenium alone or with cad-

[1] Mineral Industry, Vol. XX, p. 667.
[2] *Journ. Ind. Eng. Chem.*, July, 1912, Abstr. from *Sprechsaal*, Nos. 14 and 15, 1912.
[3] *Eng. and Min. Journ.*, July 27, 1912
[4] *Chem. Zeit.*, p. 1149, 1912; abstr. *Journ. Soc. Chem. Ind.*, p. 1033, 1912.

mium sulphide for producing a red or orange "stain." In 1894, Spitzer used selenites or selenates in conjunction with sulphites or arsenites, the latter acting as reducing agents. A year later selenium in combination with gold was employed for red colors and as a decolorizer in white glass. For discharging the green color due to iron, selenium is a valuable agent. In order to study the physical and chemical condition of selenium in glass, the author used a glass of the formula: $6SiO_2CaO2Na_2O$, which was heated for 24 to 30 hr. at 1400° C. He finds that the element selenium can only produce a red under strongly reducing conditions. The pigment is in a condition of true solution, but if by insufficient reduction the "stain" is not fully developed it is not all dissolved. The coloration depends on the reduction and not on temperature nor length of firing. There may also exist in solution, in a colloidal state, selenites of the type, $M_2Se$, and compounds less oxidized than selenites, of a type similar to thiosulphates. These colloidal solutions are sometimes colored, sometimes not.

In the Omaha plant of the A. S. & Ref. Co.[1] in treating the fume collected in the blast furnace baghouses, a speiss-like material is smelted out by an increased heat and some of this material is collected from the slag in the form of buttons in the pots. The analysis is as follows: Pb, 62 per cent., Cu, 3 per cent., Fe, tr, S, 2 per cent., As, 4 per cent., Sb, 2 per cent., Te, 19 per cent., Se, 2 per cent.

The market for pure tellurium is small and unsatisfactory, but it is recovered from this material by a special chemical process. One American firm is willing to by in large quantities at $1. per lb.; this is less than the cost of the pure tellurium, although 85 to 92% tellurium can be produced more cheaply.

According to the Government Annual, the selenium produced in Bavaria in the Zweibrucken district, in 1911, amounted to 0.712 tons valued at 4272 marks. This is the first production. A production of 750 kg. was reported for Germany in 1910.

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[1] A. Eilers, *Eighth Int'l. Congr. Appl. Chemistry.*

# SILICON CARBIDE

By F. J. Tone

production of silicon carbide in the United States during 1912 42,550 lb., which is the highest production in the history of the . The progress of the industry may be seen from the following production from 1892 to 1912:

PRODUCTION OF CARBORUNDUM IN THE UNITED STATES.

| Year. | Pounds. | Metric Tons. | Value. |
|---|---|---|---|
| ..... | 2,145 | 1 | ..... |
| ..... | 15,200 | 7 | ..... |
| ..... | 52,190 | 24 | ..... |
| ..... | 225,930 | 102 | ..... |
| ..... | 1,190,600 | 540 | $365,612 |
| ..... | 1,242,929 | 564 | 153,812 |
| ..... | 1,594,152 | 724 | 151,444 |
| ..... | 1,741,245 | 791 | 156,712 |
| ..... | 2,401,000 | 1,089 | 168,070 |
| ..... | 3,838,175 | 1,742 | 268,672 |
| ..... | 3,741,500 | 1,698 | 261,905 |
| ..... | 4,760,000 | 2,160 | 333,200 |
| ..... | 7,060,380 | 3,203 | 494,227 |
| ..... | 5,596,280 | 2,539 | 391,740 |
| ..... | 6,225,280 | 2,824 | 435,770 |
| ..... | 7,532,670 | 3,418 | 451,960 |
| ..... | 4,907,170 | 2,226 | 294,430 |
| ..... | 6,478,290 | 2,938 | 388,697 |
| ..... | 10,707,110 | 4,857 | 642,427 |
| ..... | 10,376,620 | 4,707 | 622,597 |
| ..... | 12,042,550 | 5,464 | 722,553 |

ıe United States, The Carborundum Company of Niagara Falls nly producer. Manufacture is carried on in Canada and most ın countries and the importations are large but the exact figures available because in the returns of the Treasury Department no on is made between carborundum and other artificial abrasives. vay the Arendals Smelteverk started operations in April of this h a plant of 3000 h.p. It is announced that the British Abrasives ıy are about to erect a plant at Newcastle-on-the-Tyne, England, manufacture of carborundum and other abrasives, using power ed from steam.

increase in the use of carborundum has been chiefly for refrac- rposes. This field is constantly broadening but depends on a v price for the material and a very low cost of production. As a ry for special conditions the properties of carborundum make it

unexcelled. In a fire brick the aim is to obtain a coarse, porous structure to avoid cracking from changes in temperature. Carborundum, on the other hand, on account of its low coefficient of expansion, which is less than that of fused alumina and all fire clays, can be produced in forms of great density, hardness and tensile strength regardless of the porosity of structure. This property makes it valuable for charging floors of coke ovens, ingot furnaces and for the Lehr bottoms of glass furnaces.

The high thermal conductivity of carborundum which is five times that of fire clay has opened to it a large field such as saggers for potteries, zinc muffles and coke ovens. Many potteries on the Continent are now using carborundum saggers and besides obtaining a very long life there is a distinct advantage in the time required in firing the pottery. The mixture consisting of Nos. 12-14 carborundum 400 kilos, Nos. 40-60, 450 kilos and plastic clay 150 kilos is ground dry in an Alsing crusher for ten minutes. Twelve and one-half per cent. of water is added and the mixture granulated through a No. 4 screen. From this mixture the sagger is formed in a wooden mold, then pressed in an iron mold under hydraulic pressure and fired at cone 9 to 11.

Carborundum zinc muffles are made from a mixture of 40 per cent. pulverized carborundum and 60 per cent. plastic clay and grog. Each muffle weighs 30 kilos and lasts from 70 to 100 days against 40 days for the fire clay muffle. Sudden muffle failures so common with clay muffles are unknown. Carborundum muffles are not adapted for the highly refractory or calcareous ores nor for a highly oxidizing furnace atmosphere.

Carborundum in coarse granular form is used as a catalyser or refractory diaphragm in apparatus for flameless combustion.[1]

*Technology.*—F. A. J. Fitzgerald[2] describes the manufacture of silicon carbide in a plant of recent construction and points out the great care necessary to obtain a high quality of product.

"In most processes for the manufacture of carbides or other compounds which involve the reduction of an oxide, the resulting product is fusible and this simplifies in many ways the manufacturing process as compared with that of silicon carbide where the resulting product is infusible. In the production of a fusible material a moderately careful mixture of the reacting raw materials is satisfactory, since slight inequalities or lack of homogeneity in the mixture will not cause trouble provided the proportions of the constituents are correct. The conditions of silicon carbide manufacture, however, are different.

"The mixture used in the production of silicon carbide should contain

[1] *Engineering*, XCII, 487.
[2] *Met. and Chem. Eng.*, Vol. X, pp. 519–521.

theoretically 60 parts of pure silica sand and 36 parts of pure carbon. When these are thoroughly mixed and heated to a sufficiently high temperature a portion of the carbon combines with the oxygen of the silica forming carbon monoxide gas, and the silicon thus set free combines with the remainder of the carbon to form silicon carbide. During this process, however, the mixture as a whole is not fused. Certainly the sand fuses, but the volume of carbon mixed with the sand is sufficiently great to prevent the particles of silica from running together, but instead of that they react with the carbon in their neighborhood to form, first of all, a greenish-colored substance which shows no crystalline structure, and as the temperature is carried higher this is converted into the crystalline silicon carbide. There is naturally a considerable shrinkage of the mixture, for from a theoretical charge weighing 96 kg. only 40 kg. of silicon carbide are obtained, the remaining 56 kg. disappearing as carbon monoxide gas. The mixture then shrinks, but preserves generally its original form. If the heating is continued so that the temperature is raised still further the silicon carbide is decomposed, as already described, but still there is no fusion and ultimately the carbon which was in combination with the silicon is obtained as graphite.

"If a mixture containing an excess of silica is heated a reaction occurs between the silica and the silicon carbide, which results in the production of silicon, and this is just what happens in those parts of a silicon carbide furnace charge where there is an excess of silica, due to lack of homogeneity in the mixture.

"A consideration of these facts leads to the conclusion that it would be difficult to manufacture silicon carbide in a furnace different in general principles from the well-known form that has been used for the purpose during the past 20 years. Moreover, it is not difficult to understand that the manufacture is one requiring very considerable care in order to obtain a satisfactory product and at the same time to get as large an output as possible."

The question of large furnaces is discussed and the author states that no gain in efficiency is obtained in increasing the size of furnaces above 800 kw.

In a study of a small carborundum furnace W. D. Bancroft[1] has determined the relation of the yields of carborundum, siloxycon and graphite to the length of run. The yields of these three products follow a straight line for some time. Then comes the beginning of a stationary period in the formation of carborundum indicating the end of efficient operation. The rate of graphite yield begins to decrease and the rate of siloxycon yield to rapidly increase, showing that the energy per square

[1] *Trans. Am. Electro-chem. Soc.*, Vol. XXII, p. 73.

inch of radiating surface is no longer sufficient to form crystalline product and all the energy goes to the formation of the amorphous.

*Physical Constants.*—The temperatures of formation and decomposition of silicon carbide have been determined by L. E. Saunders,[1] and his results confirm earlier investigations of S. A. Tucker[2] and H. W. Gillett.[3] Saunders found the formation point to be 1840° ±30° and the decomposition point 2240° ±5°.

P. A. Boeck[4] has determined the coefficient of expansion of silicon carbide between 100° and 900° as 0.00000474.

## Recent U. S. Patents.

No. 1014199. E. G. Acheson. A tough refractory form of silicon carbide containing boron.

No. 1023485. Thowless. A heating body for incandescent lamps composed of silicon carbide.

No. 1027004. B. Schwerin. A process for producing porous diaphragms by burning the molded article of silicon carbide powder in a non-oxidizing atmosphere.

No. 1042844. F. J. Tone. A plastic refractory furnace lining consisting of silicon carbide, fire clay and silicate of soda.

No. 1048231. Thoms. A method of making carborundum lamp filaments from vapors of silicon tetrachloride, hydrogen and ethylene gas.

Nos. 1054371, 1054372, 1054373, 1054380. F. J. Tone and T. B. Allen. The silicidizing of articles containing carbon and production therefrom of dense refractory bodies of silicon carbide containing no foreign binding material.

No. 1056069. Surmont. A paving or sidewalk composition containing carborundum.

No. 1058800. E. S. Smith and F. J. Tone. A porous form of silicon carbide suitable for heat insulation.

## Crystolon

Crystolon is carbide of silicon (SiC) in crystalline form. It is an electric furnace product made from coke, sand, sawdust and salt. These materials are carefully and accurately mixed and heated in furnaces to a temperature between 1820 and 2250° C. Each electric furnace consumes about 1000 h.p.

[1] *Trans. Am. Electro-chem. Soc.*, XXI, 425.
[2] *Journ. Am. Chem. Soc.*, 1906.
[3] *Journ. Phys. Chem.*, March, 1911.
[4] *Trans. Am. Cer. Soc.*, XIV, 476.

The Norton Company, Worcester, Mass., erected a plant for the manufacture of carbide of silicon at Chippawa, Ont., Canada, in 1910 and the current was turned on for their first electric furnace run on July 26 of that year. Previous to this time, carbide of silicon was known only by the name carborundum.

The manufacture of the material at first was under the supervision of Mr. F. A. J. Fitzgerald, a pioneer in the manufacture of carbide of silicon and a chemical engineer of international reputation. The Norton Company gave to their product the trade name crystolon.

The arrangement of the furnaces, electrical connections, size, shape and design are in accordance with the most advanced ideas of electric furnace construction. It has been the intention of the company from the beginning to make a product of the highest grade and to accomplish this end they have carried on extensive research and experimental work.

A paper presented before the American Electrochemical Society in Boston, Mass., April 18 to 20, 1912, by L. E. Saunders gives results of some interesting tests in temperature measurements on the silicon carbide furnace.

An average of the results of extensive tests conducted at the Chippawa Plant, with the greatest departure from it given as plus or minus, are:

Formation point, fire-sand, 1600° ± 50°;
Formation point, crystalline silicon carbide, 1840° ± 30° and decomposition point of silicon carbide 2240° ± 5°.

Crystolon is used chiefly in the manufacture of Norton Crystolon Grinding wheels, sharpening stones, rubbing bricks, razor hones, grinding compound and in grain form for polishing purposes.

# SODIUM AND SODIUM SALTS

In the sodium industry in the United States, nothing new has developed. The Virginia Electrolytic Co. and the Niagara Electrochemical Co. are the two manufacturers. The latter company uses the Castner process, caustic being the electrolyte and hydrogen a waste product. The annual production of sodium is estimated at 2000 tons. The uses are increasing. Some details as to recent practice, are given in MINERAL INDUSTRY, Vols. XIX and XX. A number of factories have been started in foreign countries. One is reported at the Sognefjord, north of Bergen, Norway. The manufacture of metallic sodium, sodium peroxide, and other compounds, is to be undertaken under the title of Frederiksstad Elektrochemiske Fabriker, Frederiksstad, Norway. It is reported that a factory at Vadheim, Norway, produced 179 tons of sodium in 1909, at a cost of $0.243 per pound. No imports of sodium are reported into the United States.

## NITRATE OF SODA

The largest consumer of nitrate is Germany. The production of Chile nitrate in 1912, amounted to 54,167,875 quintals (101.44 lb. each) as compared with 55,100,000 quintals in 1911. The world's market for nitrates appears to be large enough to consume both the natural and artificial products. Atmospheric nitrates are now produced on a commercial scale in Norway. For details of this industry see article on "Nitrogen Fixation." In the Unites States this industry is in its infancy, and no production is noted. The imports of sodium nitrate into the United States are given in the following table:—

IMPORTS OF SODIUM NITRATE INTO THE UNITED STATES. (a)
(In tons of 2240 lb.)

| Year. | Quantity. | Value. | Value per ton. | Year. | Quantity. | Value. | Value per ton. |
|---|---|---|---|---|---|---|---|
| 1902..... | 205,245 | $5,996,205 | $29.21 | 1908..... | 310,713 | $11,385,393 | $36.64 |
| 1903..... | 272,947 | 8,700,806 | 31.88 | 1909..... | 422,593 | 13,281,629 | 31.43 |
| 1904..... | 228,012 | 9,333,613 | 40.93 | 1910..... | 529,172 | 16,601,328 | 31.37 |
| 1905..... | 321,231 | 11,206,548 | 34.89 | 1911..... | 544,878 | 16,814,256 | 30.86 |
| 1906..... | 372,222 | 14,115,206 | 37.92 | 1912..... | 486,352 | 16,668,404 | 34.25 |
| 1907..... | 364,610 | 14,844,675 | 40.71 | ..... | ..... | ..... | ..... |

(a) As reported by the Bureau of Statistics, Department of Commerce. The figures of value appear to be doubtful, especially with respect to the earlier years.

The nitrate of soda statistics are given by W. Montgomery & Com-y, who also make the following statements. The analysis of the Euro-n consumption for 1912 shows that Germany took in tons 888,000 nst 724,000 in 1911; Belgium, 295,000 tons against 294,000 tons; nce, 349,000 tons against 332,000 tons; Holland, 174,000 tons against 000; Italy and Austria, 50,000 tons against 56,000 tons; United gdom, 130,000 tons against 132,000 tons. The remarkable increase in ate consumption during the past 5 years, is shown under "Con-ed in the World."

NITRATE OF SODA STATISTICS. (a)
(In tons of 2240 lb.)

| Year. | Shipments from South America. | Consumed in Europe. | Consumed in United States. | Consumed in World. | Stocks in Europe. | Visible Supply at Close of Year. |
|---|---|---|---|---|---|---|
| ..... | 1,429,000 | 1,126,000 | 175,000 | 1,324,000 | 221,000 | 794,000 |
| ..... | 1,238,000 | 1,154,000 | 192,000 | 1,364,000 | 243,000 | 617,000 |
| ..... | 1,360,000 | 1,028,000 | 214,000 | 1,259,000 | 263,000 | 660,000 |
| ..... | 1,435,000 | 1,127,000 | 265,000 | 1,412,000 | 155,000 | 654,000 |
| ..... | 1,476,000 | 1,131,000 | 275,000 | 1,447,000 | 162,000 | 672,000 |
| ..... | 1,623,000 | 1,190,000 | 308,000 | 1,547,000 | 183,000 | 674,000 |
| ..... | 1,700,000 | 1,243,000 | 355,000 | 1,636,000 | 190,000 | 733,000 |
| ..... | 1,626,000 | 1,252,000 | 350,000 | 1,658,000 | 202,000 | 695,000 |
| ..... | 2,017,000 | 1,378,000 | 309,000 | 1,732,000 | 402,000 | 928,000 |
| ..... | 2,100,000 | 1,465,000 | 407,000 | 1,938,000 | 337,000 | 999,000 |
| ..... | 2,300,000 | 1,651,000 | 501,000 | 2,241,000 | 310,000 | 969,000 |
| ..... | 2,412,000 | 1,696,000 | 550,000 | 2,355,000 | 479,000 | 1,058,000 |
| ..... | 2,478,000 | 1,908,000 | 481,000 | 2,504,000 | 310,000 | 1,004,000 |

) Statistics of W. Montgomery & Co., London.

The stocks in Chile at the beginning of 1913 were 10,200,000 quintals compared with 10,181,000 one year before. The following table s the direct shipments[1] in 1912.

DIRECT SHIPMENTS FROM CHILE, 1912.

| | Metric Quintals. | Pesos. |
|---|---|---|
| d Kingdom..... | 10,864,830 | 116,253,681 |
| any..... | 5,486,280 | 58,703,196 |
| d States..... | 4,152,220 | 44,428,754 |
| e..... | 905,800 | 9,692,060 |
| rlands..... | 812,290 | 8,691,502 |
| am..... | 777,110 | 8,315,077 |
| ..... | 507,240 | 5,427,468 |
| ..... | 260,990 | 2,792,593 |
| uay..... | 201,680 | 2,157,976 |
| ..... | 189,100 | 2,023,270 |
| esia..... | 124,030 | 1,327,121 |
| ..... | 89,480 | 957,436 |
| gal..... | 74,930 | 801,751 |
| da..... | 37,440 | 400,608 |
| ..... | 33,510 | 358,557 |
| o..... | 21,750 | 232,725 |
| ..... | 3,950 | 42,265 |
| tina..... | 3,260 | 34,882 |
| ia..... | 570 | 6,099 |
| dor..... | 220 | 2,354 |
| tal..... | 24,546,680 | (a) 262,649,476 |

) The total value of 262,649,476 pesos equals $95,767,059 U. S. coia.

Bulletin Pan American Union.

In 1888, the consumption of nitrate in Europe was just about what the American consumption is to-day. It is believed that, realizing the value of this fertilizer, the consumption in the United States will increase shortly to 2,000,000 tons per year. Nitrate was first introduced into Europe, in small shipments, as early as 1821. From 1825 to 1845, an import duty of 12s. per ton was proposed on nitrate entering the United Kingdom.

Prices in the latter part of 1912, had an upward tendency. The value of arrived cargoes in early July, was 9s. 11d. per cwt., cost and freight. In October the price had risen to 10s. 8d., and a little later it was 10s. 4d., the lowest price touched. Nitrate prices, f.o.b. Chile, rose from 8s. 1d. per quintal in July, for prompt shipment, and to about 8s. 10d. in October. Business for 1913–1914, took place between July and October, at 7s. 10d. to 8s. 2d. Some business took place for 1915, at 8s. 1d. per quintal.

In the American market at the beginning of 1912, prices were quoted at $2.20 per 100 lb., and rose to $2.60 at the end of the year. Increased cost of freights, scarcity of labor on the west coast, heavier operating expenses at the oficinas, caused the rise in price. Before the close of the year, charters were forced from 22s. to 37s., affecting the selling-price per 100 lb., about 15 cents. The wages of laborers responded to the scarcity of labor, and costs of coal, etc., were higher. A lower grade of caliche was worked in certain places. The United States does not take nitrates at the usual rate, when prices are high. It would appear that the United States does not play an important part in shaping the costs of the market, but the consumption of nitrate has increased in spite of a rise in prices.

In working the nitrates of Chile, no new developments are likely, while a number of large oficinas of more than 250,000 tons' capacity has been recently started, the consumption does not appear to be governed by the capacity of the works. The price maintained by the Union is high. There is no interest in changing or improving technical methods. In 1911 the nitrogen contents of the shipments may be estimated at 350,000 tons. The world's production of nitrogen in the form of sulphate of ammonia, during the same year, may be taken as 250,000 tons. The by-products of the industry, are iodine and some chlorate of potash and soda. The region extends along a belt 70 km. from the ocean and eastward. One hundred and sixty factories employed about 43,000 workmen. The annual coal consumption is about 600,000 tons. According to Belisario Diaz Ossa, Santiago, Chile,[1] a factory producing 50,000 metric quintals per month, with 20 to 25 per cent. caliche, requires a solution

[1] Eighth International Congress of Applied Chemistry.

vat capacity of 900 cubic meters and a crystallization vat capacity of 6000 cubic meters. Such a factory would cost about 2,500,000 francs, allowing 50 francs for every 100 kg. of annual production. With the system thus far employed, the caliche must contain at least 18 per cent. of nitrate, and the cost of treatment depends practically upon the cost of coal consumed. With 50 per cent. nitrate the coal would not exceed 4 kg. per 100 of niter produced; with 18 per cent. caliche, the same production requires 25 kg. of coal. A kilogram of nitrogen in the product on board ship in Chile, is sold for an average of 88 francs, the selling-price being divided as follows:

| | |
|---|---|
| Exportation duty | 41 per cent. |
| Materials (sacks, coal, powder, etc.) | 6 per cent. |
| Loading and commissions | 11 per cent. |
| Over-head charges | 3 per cent. |
| Labor | 19 per cent. |
| Coal | 11 per cent. |
| Interest, amortization | 9 per cent. |

The first four items are independent of the method of working and extraction, and the last three items depending upon these, may possibly be reduced. It will probably be a long time before the artificial products can have any influence on the Chilean nitrate industry. The Chilean industry is in a position to sell at a low price and can develop new territories. The exhaustion of the natural deposits is not likely for a long period.

IMPORTS OF SODIUM SALTS. (*a*)
(In tons of 2000 lb.)

| | 1908. | | 1909. | | 1910. | | 1911. | | 1912. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Tons. | Value. | Tons. | Value. | Tons. | Value. | Tons. | Value. | Tons. | Value. |
| Arseniate | 159.1 | $13,922 | 125.4 | $7,108 | 242.3 | $14,368 | 84.2 | $5,199 | 178.3 | $11,195 |
| Ash | 1,979 | 41,607 | 2,220 | 48,674 | 2,495.0 | 55,262 | 1939.1 | 43,365 | 1452.7 | 33,459 |
| Bicarbonate | 42.6 | 2,555 | 60.9 | 4,821 | 73.2 | 4,472 | 42.6 | 2,634 | 55.0 | 3,193 |
| Bichromate and Chromate | 54.0 | 4,304 | 1,206 | 97,661 | 1,332.1 | 101,687 | ..... | 1 | ..... | ..... |
| Caustic | 566 | 31,716 | 391 | 24,742 | 519.4 | 33,882 | 1,492.1 | 73,968 | 465.3 | 28,937 |
| Carbonate (Crystal) | 30 | 1,937 | 84 | 3,464 | 69.9 | 2,569 | 152.6 | 4,235 | 177.3 | 5,616 |
| Chlorate | ..... | ..... | ..... | 12 | ..... | ..... | ..... | 2 | ..... | 22 |
| Chloride (Salt) | 168,686 | 471,476 | 145,678 | 437,892 | 138,376.2 | 374,420 | 141,227.8 | 390,043 | 145,041 | 379,539 |
| Hyposulphite | 6 | 448 | 6 | 312 | 22.3 | 626 | 14.7 | 612 | 4.3 | 277 |
| Nitrate | 329,605 | 12,547,611 | 353,558 | 12,583,417 | 542,334.0 | 16,548,036 | 546,394.6 | 17,101,155 | 481,786 | 15,427,904 |
| Nitrite | 100 | 10,015 | 76 | 7,258 | 566.3 | 52,237 | 238.8 | 21,205 | 487.3 | 47,399 |
| Phosphate | 13 | 619 | 25 | 707 | 31.0 | 1,045 | 22 | 750 | ..... | ..... |
| Prussiate | 857 | 129,082 | 981 | 123,880 | 649.9 | 76,648 | 598 | 66,971 | 823.2 | 90,654 |
| Sal Soda | 249 | 3,419 | 252 | 3,231 | 241.1 | 4,630 | 107.2 | 1,512 | 126.8 | 2,020 |
| Salt Cake | 208 | 2,169 | 18 | 767 | 3,928.0 | 40,640 | 11,398.1 | 121,218 | 659 | 8,394 |
| Silicate | 744 | 13,376 | 509 | 8,578 | 599.5 | 12,994 | 617.3 | 11,713 | 466.6 | 8,870 |
| Sulphide | 300 | 9,539 | 267 | 7,764 | 298.3 | 9,086 | 228.0 | 4,751 | 361.5 | 10,456 |
| Sulphite | 58.5 | 3,259 | 235.4 | 10,150 | 125.5 | 4,082 | 493.7 | 14,810 | 177.1 | 4,860 |

(*a*) For fiscal years ending June 30.

Nitrate deposits in the United States have been described by H. S. Gale.[1] The value of the nitrate deposits at Morrison's siding and at Sperry, Amargosa Valley near Tecopa, Cal., is problematical. E. E. Free[2] describes the occurrence of these clay beds supposed to be tertiary.

The deposits of nitrate, 6 miles east of Queen, N. M., are not of sufficient size to be commercially important. As far as present discoveries are concerned, few of the indications warrant much outlay for developing in order to obtain a commercial source of nitrate.

## Soda

In the United States the developments in California were satisfactory. Construction of the Saline Valley Salt Co. plant, in Inyo County, California was nearing completion at the close of the year. The Natural Soda Products Co. completed its vat system and pumping station near Keeler. The Foreign Mine Development Co. introduced auto trucks for hauling its soda product from Borax Lake to Searles, on the Nevada & California Railroad.

The exports of crude natural soda from Egypt were 1207 tons in 1911. The caustic soda exported in addition amounted to 752 tons. These products and salt are from the Wadi deposits, west of the Nile, northwest of Cairo in the Lybian desert. The water in a chain of lakes, some of which are dry in summer, contain natural soda in solution, the sodium carbonate varying from 1.1 to 6 per cent. and the sodium sulphate from 2 to 6 1/2 per cent.[3] Lake Magadi, East Africa, has been worked for soda and will supply large quantities when the railway under construction connects to the Uganda Railway. The lake comprises 30 square miles. A report has been made by Mr. Cavicchioni in which he describes the lake as being solid soda.

Large quantities of soda are reported 20 miles from Pretoria, South Africa. Bore holes are being put down and a syndicate from Johannesburg is to work the deposit. The location is called the Salt Pans near Haman's Kraal.

## The Soda, Alkali, etc., Industry

The soda industry was founded originally on the anmonia soda process. Ernest Solvay first perfected his process in the factory at Couillet near Charleroi, Belgium. No Leblanc plants have been built since 1883, and only 100,000 tons out of a total of 2,000,000 tons of soda are produced

[1] *Bull.* 523, of the United States Geological Survey.
[2] Nitrate prospects Amargosa Valley, *Circ. Bur. Soils*, No. 73, U. S. Dept. Agriculture, Dec. 26, 1912.
[3] A. Lucas, Natural Soda Deposits in Egypt. *Surv. Dept. Paper*, No. 22, Govt. Press, Cairo, 1912.

now by the method. The supply of salt used by the Solvay Company at Couillet comes from France. At these works 520 men are employed. The only enlargement of the plant has been to provide electrolytic manufacture of caustic soda and chlorine.

In France the Solvay Co. controls the works at Dombasle and Salin-de-Giraud, employing 2500 men, and producing nearly enough soda to supply the domestic demand, namely, 150,000 tons. At the English branch of the Solvay Co. Brunner, Mond & Co., employs in five large works 4000 men. The annual production one-half of the English output being 200,000 tons. In Germany the Solvay Co. has five factories, employing 5000 workmen and 21,000 h.p., manufacturing more than one-half the soda required in Germany. The Spanish factory of the Solvay Co. at Torrelavega employs 600 workmen. The Russian factories are three in number, employing 2500 men. In Austria-Hungary there are five factories.

In the United States two factories, one at Syracuse, N. Y., and the other at Delray, Mich., manufacture soda under the Solvay process, and they are among the largest in the world.

*Belgium.*—The Honigmann process and the Mallet-Bolouvard system and modified ammonia soda process are employed in other factories in Belgium under the Solvay ownership.

At the Couillet works the loss of ammonia is now reduced to 1 lb. of ammonium sulphate per 100 lb. of soda. Thirty years ago it was 4 lb.

The raw material for every 100 lb. of soda is 180 lb. of 95 to 98 per cent. rock-salt. The limestone consumed is 80 lb.; the coal 80 lb. and the coke 15 lb.; representing a total cost at existing prices of $9.50 per metric ton. The Solvay enterprises have maintained a very low rate for selling the product.

In one factory in Belgium, soda is still produced with the use of cryolite and limestone. This gives a by-product of sodium aluminate, which is usually made into precipitated alumina.

Soda ash is imported into Belgium, chiefly from France, at the rate of about 29,000 tons per annum. The exports, however, were 37,600 tons in 1910. The average export price of soda-ash, was $20.75 per ton. The domestic consumption goes mostly to glass works and the textile industries.

In Belgium, in addition to the Solvay works, twenty small factories produce sal soda, including mixed salt with sulphates, and also Glauber's salt. The annual output of these salts is estimated at 40,000 tons.

The Solvay Co. in Belgium supplies about 2000 tons of solid caustic soda. The factory at Jemeppe produces this caustic electrolytically.

Here the Castner-Kellner method is modified, using only large single cells containing salt solution. A current of mercury enters slowly on one side of the cell, while a layer of sodium amalgam (0.2 per cent. Na) flows off on the other side, the salt solution moving in opposite direction. The amalgam is decomposed by steam in separate vessels, forming caustic soda and mercury to be used again.

Solutions containing over 20 per cent. NaOH are easily obtained. The chlorine liberated in the process is used for bleaching powder. The annual production in Belgium of this substance exceeds 6000 tons.

Rock-salt is brought from Germany into Belgium for the purpose of making nitric-acid. The by-product, sodium sulphate, is consumed in the glass works which are usually adjacent. The domestic supply is not sufficient for this industry, and an annual import in addition of 50,000 tons of sodium sulphate, is made.

*Canada.*—The Canadian Alkali Company bought a large tract of salt-bearing land near Sandwich. A factory is to be erected which will rival the industry on the American side.

The imports of soda products during the calendar year 1911 are as follows: Soda ash, 44,682,937 lb. valued at $375,132; caustic soda, 13,708,922 lb. valued at $253,612; sal soda, 10,202,422 lb. valued $64,107; sulphate of soda, 13, 782,241 lb. valued at $88,761.

*France.*—Manufacture of caustic soda is a large industry. In 1910 about 10,000 tons was exported largely to Belgium. Imports amounted to about 700 tons mostly from Great Britain. The exports of soda ash are twenty times the imports. In January, 1912, the price of soda ash at Havre was 1 cent per pound, caustic soda 1.3 cents per pound. The industry centers in the northeast in the department Meurthe-et-Moselle.

*Germany.*—Probably all the export business is in the hands of Brunner Mond & Co., and the United Alkali Co. (of London). Exports of sodium carbonate amounted to 57,111 tons in 1910 and 60,102 tons in 1911. Switzerland and Belgium are the largest consumers. The caustic soda exports in 1910 totalled 9237 tons and in 1911 10,635 tons; Switzerland is the largest importer. Prices early in 1912 were: For fused caustic 127° to 129° $3 per 100 lb. including drums; 70 to 72 per cent. caustic f.o.b. Hamburg, $1.99 per 100 lb.; 76 to 78 per cent. $2.33 per 100 lb. It is said that one condition of sal is that the material shall not be shipped to the United States.

*Italy.*—The mineral districts of Milan and Rome have an annual production of caustic soda of about 8500 tons and of soda ash 1500 tons. Imports in 1910 amounted to 16,000 tons of caustic and 45,000 tons of soda ash. The caustic comes chiefly from Great Britain, the soda ash from France.

*Russia.*—Imports of foreign soda are decreasing. The consumption of calcined soda now amounts to 90,000 tons per annum; the imports are only 1500 tons. The manufacture of caustic soda in 1911 was 50,000 tons and the imports only 500 tons. The industry in Russia is developing rapidly.

*Other Countries.*—Holland consumed 32,200 tons of soda in 1911, largely imported. India imported during the fiscal year (March), 1912, caustic soda and carbonate worth $147,128. Imports of caustic soda into Kobe, Japan, in 1911, amounted to 10,170,953 lb. valued $250,875, nearly all from Great Britain. The amount of soda ash imported was 21,889,980 lb. in 1911. Mexico imports 400 tons of caustic from the United States, and 2800 tons from Europe per year. The soda ash is about 300 tons from the United States and 80 tons from Europe. The consumption of caustic in Peru is about 500 tons per year, 70 per cent. of which is imported from England. Soda ash consumed amounts to 40 tons.

*Technology.*—Bleach. Experiments to show the relation of cost of power and of salt and what are the cheapest conditions for any locality to obtain the minimum cost for available chlorine, were made by Wm. H. Walker and Ralph E. Gegenheimer.[1]

The Wilderman cell has been in use at the Zellstoff fabrik Waldhof, Mannheim, Germany, for the production of 10,000 tons annually of bleach, and there have been 16 months of uninterrupted production. The installation is being increased for a production of 15,000 tons per annum. The amalgam formed at the cathode is stirred into the mercury. A description of the cell, etc., is given by Dr. M. Wilderman.[2] Inferior salt solutions containing 4 per cent. sulphates can be used without difficulty. No danger of solid amalgam is present and high densities of current (70 amp. per sq. dcm.) can be used. This also does away with excessive hypochlorites (0.04 per cent. in the brine). The efficiency of the cell is 94 per cent. when specially attended, but in practice is 92 per cent. for bleach and 90 per cent. for caustic. The consumption of graphite anodes is a minimum. The cell is capable of working with potassium salts giving a concentration of 20 per cent. KOH. The two systems successful on caustic potash are the Greisheim, at Greisheim, Elektro chemische Werke, Bitterfeld, Westeregel and the Bell system at Aussig, Austria, and also at Salzbergwerk, Neu-Stassfurd, Chemische Fabrik Buckau.

[1] *Eighth Int'l. Cong. Appl'd. Chem.*, Vol. XXI, p. 127.
[2] *Eighth Int'l. Cong. Appl'd. Chem.*, Vol. XXI, p. 185.

# SULPHUR, PYRITES AND SULPHURIC ACID

By Edwin C. Holden

## Sulphur

The world's supply of sulphur during 1912, was, as in recent years, obtained chiefly from Louisiana and Sicily. Shipments from Sicily all told in 1912 were 447,292 metric tons as compared with 453,826 tons in 1911. The increase in shipments over 1910 (when they were 393,987 tons) and the decrease of over 100,000 tons in Sicilian stocks during 1912, must be considered in judging the industry.

The imports of crude sulphur into the United States during 1912, were 26,885 tons worth $494,778, whereas in 1911 such imports were 24,250 long tons valued at $436,725; the exports rose from 28,103 tons worth $545,420 in 1911, to 57,736 tons worth $1,076,414 in 1912, or nearly twice the tonnage and value. The refined sulphur from Sicily to the United States, has declined again to a low point as was the case in 1907.

In the United States also in addition to a strong export trade, the domestic production more than doubled, largely due to the chief producer the Union Sulphur Co. in Caleasieu parish, Louisiana, which has established foreign selling agencies and adopted a policy of accumulating large stocks in Louisiana in order to supply the world's trade. This increase is for the first time reported in its true magnitude; the actual production was pushed in 1912 to the capacity previously planned.

*Markets.*—Prices in the United States were steady throughout 1912, quotations being $22 per ton at New York and $22.50 at by-ports. No Sicilian crude was imported in 1912, although a few thousand tons of refined sulphur came from that source, and about the normal amount was imported from Japan at Pacific ports. There was a good demand for sulphur in Europe; as the estimated output of the Consorzio was only about 370,000 tons and shipments increased to 470,000 tons, the Sicilian stocks were reduced by approximately 100,000. Two or three of the Sicilian mines with a normal outout of 40,000 tons were closed most of the year by reason of persistent fires and other causes, and it would appear

that sulphur bids fair to have a good market in 1913 with a somewhat restricted production.

In the Western States the free admission of Japanese sulphur has apparently not affected the market.

The rising quotations for pyrite are still in evidence, but sulphur prices are steady probably at a high level. Whether new developments in the United States will cause sufficient competition to lower the sulphur prices will be a matter of some years to determine. Undoubtedly sulphur can be produced at a lower figure if trade conditions make this necessary.

SULPHUR IMPORTS AND EXPORTS OF THE UNITED STATES.
(In tons of 2240 lb.)

| Kind. | 1907. | | 1908. | | 1909. | | 1910. | | 1911. | | 1912. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Amt. | Value. | Amt. | Value. | Amt. | Value. | Amt. | Value. | Amt. | Value. | Amt. | Value. |
| Imports. | | | | | | | | | | | | |
| Crude..... | 20,399 | $355,944 | 20,118 | $318,577 | 26,914 | $458,954 | 28,647 | $495,988 | 24,250 | $436,725 | 26,885 | $494,778 |
| Flowers.... | 1,458 | 41,216 | 793 | 22,562 | 770 | 23,084 | 912 | 30,180 | 3,891 | 83,491 | 1,310 | 39,126 |
| Refined.... | 606 | 14,589 | 692 | 17,227 | 966 | 26,021 | 985 | 25,869 | 986 | 24,906 | 1,665 | 40,933 |
| Precipitated ..... | 60 | 8,426 | 30 | 4,012 | 58 | 7,565 | ..... | ..... | ..... | ..... | ..... | ..... |
| Total imports.... | 22,523 | $420,175 | 21,633 | $362,378 | 28,708 | $515,624 | 30,544 | $552,037 | 29,127 | 545,122 | 29,860 | $574,837 |
| Exports. | 359,25 | 734,749 | 27,894 | 561,534 | 37,152 | 736,928 | 30,742 | 552,941 | 28,103 | 545,420 | 57,736 | 1,076,414 |

Exports of domestic sulphur from the United States in previous years were:

| Years. | Long tons. |
|---|---|
| 1902..... | 1,253 |
| 1903..... | 967 |
| 1904..... | 2,493 |
| 1905..... | 1,713 |
| 1906[1]..... | 14,419..... |

[1]1906 not complete.

Not included in the imports of crude foreign sulphur are 1015 tons valued $20,314 re-exported in 1912.

The following table of consumption is retained, but the figures are only for comparison with previous years. Actual consumption cannot be calculated because stocks of sulphur are not known, and the imports of pyrite used for the sulphur content are probably low.

CONSUMPTION OF SULPHUR IN THE UNITED STATES.
(In tons of 2240 lb.)

| Source. | 1905. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|---|
| Sulphur—Domestic production. | 215,000 | 294,000 | 307,806 | 307,761 | 303,000 | 259,699 | 206,200 | 787,663 |
| Imports | 84,579 | 64,646 | 20,318 | 20,118 | 26,914 | 28,647 | 24,250 | 26,885 |
| Total | 299,579 | 358,646 | 328,124 | 327,879 | 329,914 | 288,346 | 230,450 | 814,548 |
| Exports | 1,713 | 14,419 | 35,925 | 27,894 | 37,152 | 30,742 | 28,103 | 57,736 |
| Consumption. | 297,866 | 344,227 | 292,199 | 299,985 | 292,762 | 257,604 | 202,347 | 756,812 |
| (a) Sulphur contents | 291,909 | 337,342 | 286,355 | 293,985 | 286,906 | 252,452 | 198,300 | 741,676 |
| Pyrites—Domestic production. | 224,980 | 225,045 | 261,871 | 206,471 | 210,000 | 223,700 | 299,904 | 337,243 |
| Imports | 515,722 | 533,346 | 627,985 | 668,115 | 692,385 | 806,590 | 1,001,453 | 964,478 |
| Total | 740,702 | 758,391 | 889,856 | 874,587 | 902,385 | 1,030,290 | 1,301,357 | 1,292,213 |
| Exports | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Consumption. | 740,702 | 758,391 | 889,856 | 874,587 | 902,385 | 1,030,290 | 1,262,540 | 1,292,213 |
| (b) Sulphur in domestic | 98,991 | 99,020 | 115,223 | 90,847 | 92,400 | 98,428 | 131,958 | 148,387 |
| (c) Sulphur in foreign | 242,389 | 250,673 | 295,153 | 314,015 | 325,420 | 379,097 | 470,683 | 453,305 |
| Total sulphur content | 341,380 | 349,693 | 410,376 | 404,862 | 417,820 | 477,525 | 602,641 | 601,692 |
| Grand total sulphur consumption. (e) | 633,289 | 687,035 | (d)696,731 | (d)698,847 | 704,726 | 729,977 | 800,941 | 1,343,368 |

(a) Includes crude and refined sulphur. Sulphur content of crude is computed at 98 per cent. (b) Computed at 44 per cent. (c) Computed at 47 per cent. (d) This figure is in excess of the true consumption as a large percentage of the domestic output of sulphur was stored. (e) The above totals are of course exclusive of by-product sulphur.

## Sulphur Mining in the United States

*Colorado.*—Volcanic sulphur deposits existing 25 and 30 miles southwest of Creede, are described by E. S. Larsen and J. F. Hunter.[1]

*Louisiana.*—The Union Sulphur Company with its properties in Calcasieu parish, continues to be the controlling American producer. Its output as stated above was increased enormously, although much sulphur is allowed to remain in stock as mined. The figures reported are nearly 800,000 tons; the sales for the year are estimated at 302,342 long tons. It is now planned to enter the European market on a large scale. For this purpose facilities are now provided at the distributing centers, viz., Rotterdam, Harburg (near Hamburg), Marseilles and Cette. Shipments to Rotterdam are the last ones to be started. Here the Government gave a lease of 25 years to a tract of land 330×420 ft. on the waterfront. A new refinery and storage are also under construction. The refineries and storage at Cette and Marseilles are established some time. Two new steamers were added to the company's fleet in 1912; the sulphur is practically all carried in the Company's own vessels.

[1] *Bull. 530, U. S. Geol. Surv.*, 1913, p. 363.

A description of Louisiana sulphur deposits is given in MINERAL INDUSTRY, Vol. XVIII, p. 644.

The theory of the origin of the deposits was discussed by Lee Hager,[1] and by Prof. G. D. Harris.[2]

The Frasch process for recovering sulphur as applied in the Louisiana field, is described in MINERAL INDUSTRY.[3]

*Texas.*—A new operation, using the hot-water process, was undertaken by the Freeport Sulphur Co. near the mouth of the Brazos River in Texas 40 miles from Galveston. This company, backed by important capital, completed a plant for the operation of the sulphur deposits underlying Bryan Heights, and late in November a demonstration run was made in which some sulphur was pumped, the exact figures not being available. The plant was then shut down for various adjustments. "Steaming" was to be resumed early in 1913. The productive ability of this operation will be determined during 1913.

Prior to the use of the Frasch process the sulphur encountered in boring for oil was of little use. About 760 ft. of gravel and caprock overlies the sulphur bearing limestone, dolomite and gypsum, which are 150 ft. thick. Beds of pure sulphur up to 7 ft. in thickness were also met with. At a depth of 900 to 1100 ft. the borings show gypsum and rock salt, at present of no commercial importance. A core of one of the early holes was as follows: 174 ft. of sulphur formation, 35 ft. being limestone and gypsum showing less than 10 per cent. sulphur; and 85 ft. of gypsum with 10 to 50 per cent. sulphur, 54 ft. missing being probably friable sulphur and gypsum.

The first steaming unit is to have a capacity of 120,000 tons annually. Four 750 h.p. stirling water tube boilers will deliver steam at 100 lb. pressure; fuel oil will be used under the boilers. The 2,400,000 gal. of water pumped each day are obtained from six wells. The water is heated to 350° F. Two air compressors one for high and one for low pressure are also part of the installation.

The costs in extracting the sulphur in this formation under conditions similar to those in Louisiana, promise to be low. The Freeport company has an added advantage of being near tidewater. The area drilled is also said to be large.[4]

The Commercial Acid Co., of St. Louis, has sulphur refining works at Texarkana, Texas, but the sulphur used does not come from the state.

*Utah.*—The deposit in the canyon of the San Rafael River, 18 miles

[1] "The Mounds of the Southern Oil Fields," *Eng. and Min. Journ.*, Vol. LXXVIII, pp. 137–139 and pp. 180–183, 1904.

[2] *Bulletin* No. 7, Geological Survey of Louisiana, on "Rock Salt, its Origin, Geological Occurrences and Economic Importance in the State of Louisiana," 1908; The Geological Occurrence in Louisiana and Texas, *Econ. Geol.*, Vol. IV, pp. 12–34, 1909.

[3] Vol. V, 1896, p. 514.

[4] *Eng. and Min. Journ.*, Sept. 7, 1912.

west of Green River, is described by F. L. Hess.[1] As numerous warm springs and hydrogen sulphide indicate the deposit is of a surface type. No production of sulphur from Utah was reported in 1912.

*Wyoming.*—The deposits of the Sunlight Basin, Wyo. are described by D. F. Hewett.[2] As these deposits are similar to some in northern Japan[3] and also to Cone Creek, Utah,[4] both of which have been worked, they may become of importance. The deposits at Sulphur Bank,[5] Lake Co., Cal. and those of the Aleutian Peninsula[6] are also of the same type. Production in previous years from Wyoming was as follows: 1909, $9,000; 1910, $14,000; 1911, $38,000; 1912, $20,000. The operators usually shut down during the winter. Two companies are expected to work in 1913.

## Foreign Sulphur Industry

*Canada.*—The present production of sulphite pulp, in Canada, is less by 20 per cent, than it was 5 years ago. It is claimed that 40,000 to 50,000 tons of unbleached pulp are exported from Canada to the United States annually.[7]

During the fiscal year ending March, 1912, the imports of sulphur were 45,039,790 lb. valued $465,926.

*Belgium.*—The consumption of sulphur in Belgium supplied mostly by Italy, is about 15,000 tons per year. The refineries at Antwerp, produce about 7000 tons of sublimed and stick sulphur annually.

*Egypt.*—In the *Bulletin de la Societe d'Encouragement*, Mr. Polie states that in Egypt along the Red Sea littoral, sulphur is found associated with gypsum.

*France.*—The United States shipped to Marseille, France, 16,236 metric tons crude sulphur in 1910, and 1157 tons in 1911 and 9825 tons in 1912. Sulphur from all parts *to* Cette, France, was 43,142 tons in 1910, and 59,500 tons in 1911, 76,216 tons in 1912. Of the latter 15,185 tons was from the United States.

*India.*—The value of sulphur imported into India during the fiscal year March 31, 1912, was $16,166, and sulphuric acid worth $73,318.

*Italy.*—The decline in production continues. The number of workings is descreasing. Several factors contributing to these results, are the restriction of credit for sulphur mining and the emigration of labor. The value of the crude and refined sulphur exported from Italy,[8] was $7,917,880 in 1911, and $7,532,333 in 1912. The report of the

[1] *Bull.* 530. *U. S. Geol. Surv..*, 1913, p. 347.
[2] *Bull.* 530. *U. S. Geol. Surv.*, 1913, p. 350.
[3] Mining in Japan; *Geol. Survey of Japan*, 1909, p. 114.
[4] *Bull.* 315, *U. S. Geol. Surv.*, 1906, p. 485.
[5] *Mon. U. S. Geol. Surv.*, Vol. XIII, 1888, p. 251.
[6] *Bull.* 315, *U. S. Geol. Surv.*, 1906, p. 485.
[7] *Daily Cons. and Trade Rep.*, Nov. 20, 1912.
[8] Consul James A. Smith, Genoa, Italy, *Daily Cons. and Trade Rep.*, June 13, 1913.

United States Consul of Catania, Sicily; states that the exports of sulphur to the United States from his district were 10,130 tons in 1911, valued at $199,381, and 4966 tons in 1912, valued at $91,522.

In addition to the refining of sulphur, one of the industries is the manufacture of carbon bi-sulphide. None was exported to America in 1911; 182 tons exported in 1912 represent a net gain. For 12 years a factory at Catania produced this chemical to meet local demands. In 1911 one of the large works in the United States was destroyed, and this caused purchases from abroad. Owing to the heavy duty on the product as well as on the containers, the difficulty of finding vessels to carry such a highly inflammable cargo, and to the further fact that sulphur is being produced in increasing quantities in Louisiana, it is thought that the export movement, so far as the United States is concerned, is but temporary. The exports of carbon bi-sulphide from the district to the United States in 1912, were 182 tons valued at $16,369.

The sulphur quotations, f.o.b. Catania, were about as follows: Refined $20,94; refined ground $23.16; rolled refined $21.80 and sublimed $26.63 per ton. The stock on hand at the beginning of 1912, declined from 551,420 metric tons, to 450,917 tons at the close of the year. The total production for 1911, was 373,469, and for 1912, 357,547 tons. During 1912 some of the large mines were idle on account of fire, financial difficulties, etc. The outlook is unfavorable.

The following table shows the stocks and exports from Sicily in recent years. The production is stated as follows: The production in 1906, was 471,190 tons; 1907, 399,672 tons; 1908, 404,297 tons; 1909, 402,353 tons; 1910, 397,808 tons; 1911, 376,171 tons; 1912, 357,547 tons.

TOTAL EXPORTS OF SULPHUR FROM SICILY, 1904–1912.
(In metric tons.)

| Country. | 1904.(*a*) | 1905.(*a*) | 1906.(*d*) | 1907.(*d*) | 1908.(*d*) | 1909.(*d*) | 1910.(*d*) | 1911.(*d*) | 1912.(*d*) |
|---|---|---|---|---|---|---|---|---|---|
| Austria | 23,374 | 25,111 | 24,703 | 26,390 | 22,086 | 26,560 | 29,601 | 34,136 | 38,362 |
| Belgium | 13,627 | 14,442 | 8,538 | 8,066 | 8,746 | 16,377 | 14,305 | 11,771 | 10,723 |
| France | 103,040 | 96,170 | 71,021 | 59,868 | 96,448 | 90,239 | 93,229 | 114,868 | 104,109 |
| Germany | 31,613 | 28,319 | 40,113 | 35,059 | 30,229 | 28,538 | 30,225 | 28,664 | 32,286 |
| Greece and Turkey | 25,376 | 25,069 | 25,136 | 27,969 | 24,838 | 16,309 | 21,435 | 24,933 | 15,436 |
| Holland | 8,122 | 4,425 | 10,037 | 14,951 | 9,812 | 8,708 | 9,731 | 10,549 | 14,019 |
| Italy | 79,619 | 99,633 | 81,329 | 57,743 | 60,134 | 49,692 | 61,269 | 72,959 | 84,952 |
| Portugal | 8,373 | 13,196 | 15,968 | 13,328 | 17,586 | 21,036 | 18,758 | 25,121 | 21,314 |
| Spain | 4,064 | 2,478 | | | | | | | |
| Scandinavia (*c*) | 20,120 | 18,288 | 21,605 | 23,415 | 30,366 | 19,905 | 20,354 | 29,741 | 35,111 |
| Russia | 15,141 | 16,673 | 18,174 | 21,244 | 14,068 | 18,584 | 25,866 | 23,485 | 25,563 |
| United Kingdom | 18,108 | 18,847 | 18,687 | 17,929 | 20,597 | 19,860 | 19,074 | 19,936 | 19,830 |
| United States | 100,000 | 70,332 | 37,725 | 4,047 | 9,654 | 14,706 | 12,205 | 8,482 | 2,856 |
| Other countries(*b*) | 25,167 | 23,277 | 28,591 | 31,942 | 30,509 | 33,999 | 36,935 | 49,181 | 42,731 |
| Totals | 475,745 | 456,260 | 401,627 | 341,951 | 375,037 | 364,513 | 393,987 | 453,826 | 447,292 |
| Stock in Sicily, Dec. 31 | 396,541 | 462,437 | 523,586 | 594,459 | 616,419 | 647,880 | 640,711 | 551,442 | 450,917 |

(*a*) Reported by Emil Fog & Sons, Messina. (*b*) Mainly South Africa, Northern Africa, Asia, Australia, and the East Indies. (*c*) Including Norway, Sweden and Denmark. (*d*) Reported by Parsons & Petit, New York. (*e*) Includes Canada.

*Japan.*—With one exception all the sulphur mines of Hokkaido and the northern mainland of Hokkaido, are volcanic deposits. The principal mine is located at Oshino. Other important mines are at Furutakei, Yuwaoto, Shikabe and Furano in Hokkaido. Other localities are Numajiri in Fukushima. Most of the Japanese sulphur is simply melted and sorted into several grades. The production in 1911 not including Formosa, was 50,275 metric tons. The production of Nagasaki consular district for 1911, is reported as 6,000,000 lb., valued at $37,813. Sulphur exported to the United States and possessions as declared in Japan, was valued at $361,357 in 1911 and $443,603 in 1912.

The United States imports of sulphur from Japan showed an increase of over 20 per cent., while the California production of pyrite increased over 25 per cent. but at a reduction in value of about 1 per cent. unit of sulphur as compared with 1911. These are about the only indications of any effect of the remission of duties in Japanese sulphur.

The sulphur produced in Formosa is mostly from volcanic craters; the output officially stated has been.

| | |
|---|---|
| 1906 | 801 metric tons valued at 15,876 yen. |
| 1907 | 1316 metric tons valued at 28,494 yen. |
| 1908 | 1969 metric tons valued at 44,593 yen. |
| 1909 | 2162 metric tons valued at 53,599 yen. |
| 1910 | 2245 metric tons valued at 52,725 yen. |
| 1911 | 1789 metric tons. |

*Mexico.*—The sulphur mine leased by German interests near Cerritos, San Luis Potosi was closed down during 1912. This property is reported to be the largest sulphur producer is Mexico. A small quantity was produced at other properties as heretofore.

It is reported that an English company purposes to construct a road up the volcano Mount Popocatepetl to handle the product from a sulphur bed. The elevation 17,000 ft. would make it one of the highest railways in the world.

*Netherlands.*—The Netherlands consumed annually about 550 tons of sulphur from Italy, and 1000 tons of refined sulphur from France.

*New Zealand.*—The English and Colonial syndicate has acquired White Island in the Bay of Plenty, for the purpose of mining sulphur and they are reported to be installing a plant. The island is a dormant volcano and is estimated to have 750,000 tons of sulphur.

*Spain.*—The number of mines producing sulphur ore in Spain in 1911, was two. The area of these mines was 647 hectares, and 336 men were employed. The production was 40,662 tons, valued at 286,620 pesetas at the mine.

The sociedad anónima Azufrera del Coto de Hellin produced in 1912 from 29,442 tons of 20.60 per cent. ore; 1153 tons of flowers of sulphur;

4200 tons of lump sulphur, 571 tons of ground and 40 tons of stick sulphur. Shortage of labor prevented a larger production.

*Sweden.*[1]—The pulp mills of Sweden require 72,800 tons of sulphur annually, practically all of which is imported from Sicily. This sulphur is distributed, in tons, among the various pulp districts about as follows: Skelleftea-Umea, 4600; Ornskoldsvik, 3800; Harnosand, 4500; Sundsvall, 11,900; Hudiksvall-Soderhamn, 6700; Gefle, 11,500; Norrkoping, 3200; Vestervik-Karlskrona, 2100; Halmstad, 3800; and Gottenborg-Uddevalla, 20,700.

The price of the best Sicilian sulphur per ton c.i.f. Baltic ports, varies according to the rates of freight, and sulphur has sold for $22.50 a ton c.i.f., while the freight rate was as low as $2.07. During 1912 the price was $25 per ton c.i.f. Baltic ports with a freight rate to Sundsvall of $3.35 per ton. Several years ago the matter of importing American sulphur into Sweden was taken up, but came to naught, owing to inability to solve the question of freight.

WORLD'S PRODUCTION OF SULPHUR. (*a*)
(In metric tons.)

| Year. | Austria. (*b*) (*e*) | Chile. | France. (*b*) | Germany. | Greece. | Italy. (*b*) | Japan. | Spain. | United States. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1896..... | 781 | 940 | 9,720 | 2,263 | 1,540 | 426,353 | 12,540 | 1,800 | 3,861 | 459,798 |
| 1897..... | 642 | 664 | 10,723 | 2,317 | 358 | 496,658 | 12,013 | (*b*)3,500 | 1,717 | 528,592 |
| 1898..... | 589 | 1,256 | 9,818 | 1,954 | 135 | 502,351 | 10,339 | 3,100 | 2,770 | 532,312 |
| 1899..... | 671 | 989 | 11,744 | 1,663 | 1,150 | 563,697 | 10,241 | 1,100 | 1,590 | 592,290 |
| 1900..... | 985 | 2,472 | 11,551 | 1,445 | 891 | 544,119 | 14,439 | 750 | 4,630 | 581,282 |
| 1901..... | 5,048 | 2,516 | 6,836 | 963 | 2,336 | 563,096 | 16,548 | 610 | 6,977 | 604,930 |
| 1902..... | 3,826 | 2,636 | 8,021 | 487 | 1,391 | 510,333 | 18,287 | 450 | 7,565 | 552,996 |
| 1903..... | 4,610 | 3,560 | 7,375 | 219 | 1,266 | 553,751 | 22,914 | 1,680 | 35,660 | 631,035 |
| 1904..... | 6,431 | 3,594 | 5,447 | 209 | 1,225 | 527,563 | 25,587 | 605 | 196,588 | 767,249 |
| 1905..... | 8,542 | 3,470 | 4,637 | 205 | 1,126 | 568,927 | 24,652 | 610 | 218,440 | 830,609 |
| 1906..... | 15,258 | 4,598 | 2,713 | 178 | (*d*)1,000 | 499,814 | 27,589 | 700 | 298,704 | 845,956 |
| 1907..... | 24,199 | 2,905 | 2,000 | 176 | (*d*)1,000 | 426,972 | 33,329 | 3,612 | 312,731 | 801,911 |
| 1908..... | 17,429 | 2,705 | 2,189 | 811 | (*d*)1,000 | 445,312 | 33,419 | 13,872 | 312,700 | 829,437 |
| 1909..... | 12,856 | 4,508 | 2,900 | 1,185 | (*d*)1,000 | 435,060 | 36,317 | 21,750 | 303,000 | 817,608 |
| 1910..... | 15,976 | (*c*) | 2,641 | 1,272 | (*d*)1,000 | 430,360 | 43,848 | 30,113 | 259,699 | ..... |
| 1911..... | 15,805 | (*c*) | 1,200 | 1,251 | 5 | 414,671 | 52,064 | 40,662 | 246,300 | ..... |
| 1912..... | ..... | (*c*) | (*c*) | (*c*) | ..... | 357,547 | (*c*) | (*c*) | 800,300 | ..... |

(*a*) From the official reports of the respective governments. The sulphur recovered as a by-product by the Chance-Claus process in the United Kingdom, amounting to between 20,000 and 30,000 long tons annually, is not included. (*b*) Crude mineral; limestone impregnated with sulphur. (*c*) Not yet reported. (*d*) Estimated. (*e*) Includes such production from Hungary.

## PYRITE

The production in the United States rose from 299,904 long tons, valued $1,150,597, to 337,243 tons, valued $1,276,908. An active demand on the part of some chemical manufacturers for acid was balanced by a large decrease in the requirements for fertilizer acid as a result of the unseasonably late frosts in the southern states preventing much of the spring consumption of fertilizer used in early plowing.

[1] Consul General Ernest L. Harris, Stockholm.

Virginia continues to be the largest domestic producer of pyrite; the New York production increased about 10 per cent., but was this year exceeded by that of California; Wisconsin also shows a notable increase while the remaining production was from Illinois, Ohio, Alabama and Georgia. Half of the domestic output was produced by three companies, the Arminius and the Sulphur Mines, in Virginia, and the St. Lawrence Pyrites Co., at DeKalb Junction, New York.

The imports of sulphur ore (pyrites containing over 25 per cent. of sulphur) into the United States in 1912, as reported by the Department of Commerce, were 964,478 tons, valued $3,860,738, as against 1,001,453 tons, valued $3,788,632, in 1911. This makes the total consumption of pyrite as shown in the table. Less than one quarter of the United States consumption of pyrite is now supplied by the domestic mines, nor are there prospects of important new developments or of old mines yielding increased production.

PRODUCTION, IMPORTS AND CONSUMPTION OF PYRITES IN THE UNITED STATES. (a)
(In tons of 2240 lb.)

| Year. | Production. | | Imports. (b) | | Consumption. | |
|---|---|---|---|---|---|---|
| 1898 | 191,160 | $589,329 | 171,879 | $544,165 | 363,039 | $1,133,494 |
| 1899 | 178,408 | 583,323 | 310,008 | 1,074,855 | 488,416 | 1,658,178 |
| 1900 | 201,317 | 684,478 | 322,484 | 1,055,121 | 523,801 | 1,739,599 |
| 1901 | 234,825 | 1,024,449 | 403,706 | 1,415,149 | 638,531 | 2,439,598 |
| 1902 | 228,198 | 971,796 | 440,363 | 1,650,852 | 668,561 | 1,622,648 |
| 1903 | 199,387 | 787,579 | 425,989 | 1,628,600 | 625,376 | 2,416,179 |
| 1904 | 173,221 | 669,124 | 413,585 | 1,533,564 | 586,806 | 2,202,688 |
| 1905 | 224,980 | 752,936 | 515,722 | 1,780,800 | 740,702 | 2,533,736 |
| 1906 | 225,045 | 767,866 | 597,347 | 2,138,746 | 822,392 | 2,906,612 |
| 1907 | 261,871 | 851,346 | 656,477 | 2,637,485 | 918,348 | 3,488,831 |
| 1908 | 206,471 | 744,463 | 668,115 | 2,624,339 | 874,586 | 3,368,802 |
| 1909 | 210,000 | 756,814 | 692,385 | 2,428,638 | 902,385 | 3,185,452 |
| 1910 | 223,700 | 830,150 | 806,590 | 2,773,627 | 1,030,290 | 3,603,777 |
| 1911 | 299,904 | 1,150,597 | 1,001,944 | 3,788,632 | 1,301,848 | 4,939,229 |
| 1912 | 327,735 | 1,263,928 | 964,478 | 3,860,738 | 1,292,213 | 5,124,666 |

(a) These statistics do not include the auriferous pyrite used for the manufacture of sulphuric acid in Colorado. (b) Net imports, less re-exports of 3060 tons in 1902 and 1330 tons in 1903.

By-product sulphur is not included in the above pyrite production, and the sources of this sulphur are given under sulphuric acid.

Comparing the imports for the fiscal years ending June 30, the total received in 1911 was 894,281 tons, of which 742,758 tons were Spanish and 117,996 tons Portuguese. In 1912 fiscal year 1,004,048 tons imported were valued $3,900,145. The pyrites from Spain during the calendar year 1912, is estimated at 864,872 tons and from Portugal 126,465; the balance from Canada being estimated at 25,000 tons; this is in excess of the figure in the table. This ore is free and is specified as in the natural state, and containing more than 25 per cent. sulphur.

The iron pyrite imported contains under 0.7 per cent. copper; some ore is imported, however, the copper contents of which runs from 0.7 to

1.25 per cent. and such ore has been "washed" or leached in Spain; in this way about 70 per cent. of the copper contents is extracted before shipment. In addition a higher class ore, viz. 1.75 to 2.25 per cent. copper is imported and treated by chemical works such as the Pennsylvania Salt Co., the ore classed as copper ore containing a higher percentage is also imported and treated by the copper smelters.

The ore classed as copper ore and imported from Spain in 1910, was 18,538 tons containing 4,927,830 lb. or 1.86 per cent. copper; in 1911 such ore from Spain was 139,860 tons with a copper content of 5,354,142 lb. or 1.7 per cent.; in 1912 this ore amounted to 132,921 tons with 3,487,584 lb. of copper or 1.85 per cent. copper. These imports when added to the pyrites in the table bring the total imports for 1910, 1911 and 1912, to 925,128 tons, 1,141,804 tons and 1,097,399 tons respectively and the values to $3,396,047 for 1910, $4,441,865 for 1911 and $4,636,786 for 1912. The additional values are of course to some extent in copper, but the ore is used for sulphur as well.

*Markets.*—Prices in the United States fluctuated but little. Furnace size ore was quoted at 13 to 13 1/2 cents per unit and fines at 12 cents. Domestic prices ranged from 8@ 10 cents per unit, and probably averaged 9 1/4 cents f.o.b. mines.

The importations are the controlling factor in the pyrites market. In a normal year the imports of Spanish and Portuguese ore are about 1,000,000 long tons. It is claimed that owing to the overextension of the phosphate industry in 1911, the demand in 1912 was affected and was therefore below normal. The increase in production in 1912 was not as much as expected and the imports fell short by 10 per cent. As noted under the subject of "Sulphuric Acid," the most potent cause of the shrinkage products during 1912, was the sub-normal agricultural condition. From statictics available for early 1913, the imports promise to increase over those of 1912, and at higher prices. The importations for 1912 were at an average declared value of $4 per ton and for 1911 at $3.72 per ton.

## Pyrites Mining in the United States

The pyrites industry is, through its relation to the acid production, a barometer of conditions in the fertilizer as well as in the general chemical industry. The small proportion of domestic ore entering into the consumption of pyrite and the fact that some of the important mines are not able to materially increase their outputs, leaves the industry a strongly competitive one from the consumer's viewpoint. No large

new developments are expected and indeed a number of older mines may not maintain their past rate of output.

*Alabama.*—The mines near Pyriton, Clay County, have been idle for several years. The No. 1 or Smith mine worked by an incline is described as in schist; three other mines have formerly been worked and the ore was treated in a smill now destroyed.[1]

*California.*—Through an error in the state reports received last year the production of Alameda County was given in Vol. XX of the Mineral Industry is the total for the state.

Pyrite production of the state during 1912 amounted to 69,872 tons, the value of the crude ore at the property being $203,470, or an average of $2.91 per ton. This shows an increase of 15,647 tons, and $20,516 in value, over the 1911 output of 54,225 tons valued at $182,954, although the average value per ton decreased 46 cents. The pyrite here referred to was that actually used in the manufacture of sulphuric acid, many thousand tons being annually treated for other than their sulphur content. The output by counties for the two years is as follows:

| County. | 1911. | | 1912. | |
|---|---|---|---|---|
| | Short tons. | Value. | Short tons. | Value. |
| Alameda | 6,340 | $31,352 | 7,267 | $29,068 |
| Shasta | 47,885 | 151,602 | 62,605 | 174,402 |
| Total | 54,225 | $182,954 | 69,872 | $203,470 |

*Georgia.*—As in recent years only two producers mined pyrite in the state in 1912, these were the mines at Villa Rica, 30 miles west of Atlanta and the mine of the Sulphur mining and R. R. Co. It is not known that the Chestatee deposit was prospected further; the deposit has been described by N. P. Pratt[2] and others.

*Illinois.*—The pyrite is obtained as a by-product in coal washing. In 1912 the production increased more than one-half; 27,000 tons valued $62,980 were produced.

*Indiana.*—A notable increase in the by product pyrite which results at the coal washeries is reported for 1912. In 1911 the tonnage was very small and most of the companies wasted the product. The production in 1912 is estimated at over 500 tons.

*Mass.*—The work at the Davis mine was suspended, the production being practically no concentrates for 1912. It is not considered, how-

[1] E. S. Bastin, *Mineral Resources, U. S. Geol. Surv.* for 1911.
[2] *Am. Fertilizer*, Aug. 26, 1911, p. 44. E. C. Eckel, Geology, *Bull.* 213, *U. S. Geol. Surv.*, 1903, p. 62, *Mineral Resources, U. S. Geol. Surv.*, Part II, 1911, p. 950.

ever, that the old Davis mine is exhausted. The ore is exceptionally free from impurities.

*New York.*—A prosperous year for the one large producer and for the other mines in St. Lawrence County is recorded. The St. Lawrence Pyrite Co. in 1911 mined and milled about 125,000 tons of ore, and in 1912 about 142,000 tons; the finished product, with about 45 per cent. sulphur was sold in 1911 for about 11 3/4 cents per unit per ton. In 1912 the value per ton of concentrates sold at about the same figure; the tonnage sold was increased in proportion to the crude ore. A few thousand tons of crude ore was also sold directly in 1912. The Hinckley Fiber Company also continued its production which it uses at its own paper mill; the Cole mine ore is not concentrated and runs better than 30 per cent. sulphur.

In these deposits which run from 15 to 40 per cent. sulphur some of the mineral is pyrrhotite; the milling is done on 25-ft. Hancock jigs and the tails from these retreated on Hartz jigs. The fines are treated by Wilfleys and finest slimes by Deister tables.

*Virginia.*—The state has long been the chief pyrite producer; the pyrite is shipped practically without concentration principally from Louisa and Prince William Counties. The properties furnishing the output are, in order, the Arminius, the Sulphur Mining and R. R. Company and the Cabin Branch. A slight decline in the production during 1912 may be reported, but it is not serious and with perhaps one exception will be made up in the next year. Value of product was slightly improved over that of 1911. One cause of the decline in production in 1912 was a shortage of railroad cars.

The pyrrhotite mines ship a constant output, but this is not included in the pyrite estimate, although the ore is used for sulphur at Pulaski.

A nodulizing plant is under construction at Roanoke, Va., by the Pyrites Company, Ltd., of London. The imported ore will be leached for its copper contents and the output will be about 200 tons of nodulized cinder per day. The company will also collect cinder from various Southern plants.

The total production of pyrite, inclusive of pyrrhotite in Virginia for the past seven years is as follows:

| Year. | Long Tons. | Value. | Average Price per Ton. |
|---|---|---|---|
| 1907 | 124,740 | $372,586 | $2.99 |
| 1908 | 116,340 | 435,522 | 3.74 |
| 1909 | 114,176 | 423,283 | 3.71 |
| 1910 | 140,106 | 525,437 | 3.75 |
| 1911 | 150,800 | 558,494 | 3.70 |
| 1912 | | | |

A description of the mineral deposits and mines is given by the *U. S. Geol. Surv.*[1]

*Wisconsin.*—The production of pyrite as a separate commercial product was begun seven years ago. The output rank of the state since then is indicated in the accompanying table:

ANNUAL PYRITE PRODUCTION.

| | Short Tons. | Value. | Rank of State. |
|---|---|---|---|
| 1907 | 231 | $797 | ..... |
| 1908 | 2,536 | 8,740 | 9 |
| 1909 | 7,970 | 27,337 | 7 |
| 1910 | 14,081 | 49.467, | 4 |
| 1911 | 14,470 | 50'025 | 4 |
| 1912 | 20,133 | 70,450ca | ? |

The demand for pyrite for the acid industry of the middle west is met by the output of by-product pyrite from the coal mines of Ohio, Indiana and Illinois, from the Wisconsin pyrite, from western mixed ores and from practically the entire Canadian imports of pyrite extending through Chicago. This last source is becoming increasingly important although it can only be depended upon during the shipping season on the lakes.

A number of the Wisconsin mines have developed large bodies of shipping grade pyrite above the oil rock; in addition to the pyrite and marcosite which occurs disseminated through the zinc ore and since the burning of the Huff plant at Platteville this direct source of pyrite has become more important.

WORLD'S PRODUCTION OF PYRITES.
(In metric tons.)

| Year. | Belgium. | Bosnia. | Canada. | England. | France. | Germany. | Hungary. | Italy. (a) |
|---|---|---|---|---|---|---|---|---|
| 1897 | 1,828 | ..... | 35,291 | 10,752 | 303,488 | 133,302 | 44,454 | 58,320 |
| 1898 | 147 | 3,670 | 29,223 | 12,302 | 310,972 | 136,849 | 58,079 | 67,191 |
| 1899 | 283 | ..... | 25,112 | 12,426 | 318,832 | 144,623 | 79,519 | 76,538 |
| 1900 | 400 | 1,700 | 36,308 | 12,484 | 305,073 | 169,447 | 87,000 | 71,616 |
| 1901 | 560 | 4,570 | 31,982 | 10,405 | 307,447 | 157,433 | 93,907 | 89,376 |
| 1902 | 710 | 5,170 | 32,304 | 9,315 | 318,235 | 165,225 | 106,490 | 93,177 |
| 1903 | 720 | 6,589 | 30,822 | 9,794 | 322,118 | 170,867 | 96,619 | 101,455 |
| 1904 | 1,075 | 10,421 | 29,980 | 10,452 | 271,544 | 174,782 | 97,148 | 112,004 |
| 1905 | 976 | 19,045 | 29,713 | 12,381 | 267,114 | 185,368 | 106,848 | 117,667 |
| 1906 | 908 | 13,474 | 35,927 | 11,318 | 265,261 | 196,971 | 112,623 | 122,364 |
| 1907 | 397 | 3,671 | 35,494 | 10,357 | 283,000 | 196,320 | 99,503 | 126,925 |
| 1908 | 357 | 5,000 | 42,934 | 9,599 | 284,717 | 219,455 | 95,824 | 131,721 |
| 1909 | 214 | (b) | 58,645 | 8,564 | 273,221 | 198,688 | 98,971 | 149,084 |
| 1910 | 213 | 571 | 48,871 | 10,393 | 250,432 | 215,708 | 92,464 | 165,688 |
| 1911 | 122 | 3,118 | 74,994 | 9,666 | 277,900 | 217,459 | 96,754 | 165,273 |

[1] *Min. Resources* for 1909.

| Year. | Japan. | Newfound-land. | Norway. (c) | Portugal. (c) | Russia. | Spain. | Sweden. | United States. | Total. |
|---|---|---|---|---|---|---|---|---|---|
| 1898 .. | 8,726 | 32,335 | 89,763 | 302,686 | 24,570 | 70,265 | 386 | 194,219 | 1,341,383 |
| 1899 .. | 8,376 | 26,154 | 95,636 | 347,234 | 23,250 | 107,386 | 150 | 181,263 | 1,446,782 |
| 1900 .. | 16,166 | *Nil* | 98,945 | 402,870 | 23,154 | 34,638 | 179 | 204,538 | 1,464,512 |
| 1901 .. | 17,589 | 7,532 | 101,894 | 443,397 | 30,732 | 33,953 | *Nil* | 238,582 | 1,568,999 |
| 1902 .. | 18,580 | 26,000 | 121,247 | 413,714 | 26,465 | 145,173 | *Nil* | 231,849 | 1,713,654 |
| 1903 .. | 16,149 | 42,674 | 129,939 | 376,177 | 22,780 | 155,739 | 7,793 | 202,577 | 1,692,812 |
| 1904 .. | 24,886 | 61,166 | 133,603 | 383,581 | 31,667 | 161,841 | 15,957 | 175,992 | 1,696,099 |
| 1905 .. | 25,569 | 51,534 | 162,012 | 352,479 | 30,689 | 179,079 | 20,762 | 228,580 | 1,789,816 |
| 1906 .. | 36,038 | 28,583 | 197,886 | 350,746 | 20,660 | 189,243 | 21,827 | 228,646 | 1,832,475 |
| 1907 .. | 56,166 | 28,000 | 236,038 | 241,771 | 18,316 | 225,830 | 27,000 | 266,061 | 1,854,849 |
| 1908 .. | 33,867 | (e)35,000 | 269,129 | 81,417 | 56,345 | 263,457 | 29,569 | 209,774 | 1,768,365 |
| 1909 .. | 27,066 | *Nil* | 282,606 | 284,735 | (b) | 236,000 | 16,104 | 213,371 | (e)1,730,000 |
| 1910 .. | 78,418 | *Nil* | 322,000 | 312,906 | (e)50,000 | 294,184 | 25,445 | 227,280 | 1,826,854 |
| 1911 .. | 73,879 | 2,500 | (e)350,000 | 282,773 | ..... | 344,879 | 30,096 | 299,904 | ..... |
| 1912 .. | ..... | *Nil* | (e)430,000 | (f)601,443 | ..... | 500,000 | 31,835 | 342,655 | ..... |

(a) Cupriferous in part. (b) Reports not yet available. (c) Both iron and copper pyrites. (d) Not including Newfoundland. (e) estimated. (f) Includes 120,148 tons copper iron pyrite.

## Foreign Pyrite Industry

*Belgium.*—In Belgium, 50,000 tons of leached cinder is produced annually from cupriferous pyrites. The purple ore is in demand at the blast-furnaces for iron. The roasting of pyrites in Belgium is generally done in the Maletra kiln. One works has introduced the German Humboldt mechanical kiln, but it is not established, as the cost of manual labor is low. The purple ore withdrawn from the pyrites kiln is sold to Belgium blast-furnaces, or exported chiefly to German works. The purple ore is worth from $1.55 to $1.75 per ton. Copper from the purple ore is always extracted, even when it falls as low as 0.3 per cent.

*Canada.*—The principal pyrites shippers in Canada in 1912, were the following:

Eustis Mining Co., Mine at Eustis, Quebec; East Canada Mining & Smelting Co., Weedon, Quebec; Nichols Chemical Co., Sulphide, Ontario; Canadian Sulphur Co., Ltd., Queensboro, Ontario; Northern Pyrites Co., near Graham, Ontario; Lake Superior Corporation, Helen Mine, 15 miles from Michipicoten Harbor, Lake Superior.

A comprehensive report was issued[1] which is of interest to producers and consumers of pyrite and sulphuric acid. The market in Canada, for pyrites, is four times the production. Properties that can be developed to a stage where a steady shipment of a standard grade is possible can either supply an increasing export market as at present, or the associated manufacturing industries that will develop in Canada.

In the use of sulphurous acid in the manufacture of sulphite pulp, a market for pyrites can be found, inasmuch as pyrites is cheaper than sulphur and at least one large mill is now projected in which pyrites will be used in place of sulphur.

In the Province of Quebec there are two operating pyrites mines

[1] Pyrites in Canada, by Alfred W. G. Wilson, Ph. D., Department of Mines, Canada, 1912.

with large ore reserves. They are also favorably located with reference to other industries in the St. Lawrence Valley, requiring sulphuric acid.

North of the Great Lakes a number of large ore-bodies is known exist, but the grade is not so high as that of Quebec. Even at this distance the cost is affected by the price of Spanish pyrites and the cost of sulphur.

The sulphur on the Canadian market is from either Sicily, Louisiana or Japan, the latter via British Columbia.

The consumption of pyrites for acid making near the Great Lakes exceeds 200,000 tons, but more than half the Canadian pyrites finds its way to the Eastern market, and is replaced by other ore, chiefly Spanish, transported by rail from the Atlantic Seaboard.

The Lake market on the United States side for pyrites offers possibilities for the Lake production. The difference in price between the Lake and New York will approximately represent the difference in freight between Atlantic ports and the Ontario points.

The Ontario Bureau of Mines states that during the year 1910 the average price at the mine for Ontario pyrites was $2.90 per ton.

There are no accounts of the pyrites imported into Canada in recent years and the consumption of pyrites in Canada is not easily determined. The approximate Canadian consumption of domestic pyrites is given in the following table:

APPROXIMATE CANADIAN CONSUMPTION OF DOMESTIC PYRITES, 1894–1911.

| Calendar Year. | Tons (2,000 lb.). | Calendar Year. | Tons (2,000 lb.). |
|---|---|---|---|
| 1894 | 31,995 | 1903 | 12,915 |
| 1895 | 26,493 | 1904 | 18,901 |
| 1896 | 18,713 | 1905 | 13,584 |
| 1897 | 23,814 | 1906 | 16,693 |
| 1898 | 22,414 | 1907 | 21,187 |
| 1899 | 12,086 | 1908 | 30,053 |
| 1900 | 22,411 | 1909 | 28,846 |
| 1901 | 10,290 | 1910 | 23,436 |
| 1902 | 17,032 | 1911 | 50,564 |

*Cuba.*—There are several undeveloped pyrite deposits in the Province of Santa Clara apparently of the contact replacement type. Lack of transportation has prevented exploitation hitherto, but American interests have recently taken options and will thoroughly explore the properties. The close proximity of such a source of pyrite to the Atlantic seaboard market renders it attractive.

*France.*—The exports of pyrites from Rouen, France, during the year 1911 were 1102 short tons.

*Germany.*—The pyrite produced in Bavaria in 1911 is derived from two mines which produced, with 73 men, 6,316 tons, valued at 81,652 marks. Exports and imports are noted in the table at the end of this volume.

*Greece.*—The output of pyrites in 1911 was 35,956 metric tons sold at $3.15 per ton.

*Italy.*—The pyrite produced in Italy was as follows: 1910: 135,628 tons, valued at 2,301,851 lires; 1911: 146,124 tons, valued at 2,784,873 lires. Copper bearing pyrites was also produced as follows: 30,060 tons, valued at 562,680 lires in 1910 and 19,149 tons, valued at 356,171 lires in 1911. In 1912 the production, cupriferous in part, was 277,585 metric tons.

*Mexico.*—About 20 miles from the port of Zihnatanejo, on the west coast, in Guerrero, the Copper King mine owned by the Pacific Copper Co., Ltd., has been developed by about 3500 feet of underground work reported to prove a deposit of cupriferous pyrite to a depth of 250 feet and averaging 150 to over 200 wide along 900 feet on the strike. It is claimed that over 3,500,000 tons of ore are proven that will average from 45 to 51 per cent. sulphur with varying quantities of copper. The property is still in the development stage and may ultimately become an important factor in the pyrite industry on the Pacific coast.

*Norway.*—The production of pyrites in Norway in 1912 was 400,000 to 450,000 tons. The two most important producers are Sulitjelma (situated near the polar circle and at the Swedish frontier), with a production of about 125,000 tons, and Lokken, in the Trondhjem district, producing 110,000 to 120,000 tons. The rest of the output comes from several other properties of which especially may be mentioned: Foldal, Kostvangen, Killingdal and Stordo. The iron pyrites from these mines contain copper to an average of about 2 per cent., and with a content of sulphur from 40 to 50 per cent. This pyrites is for the greater part exported. Not a small quantity, however, is also used in the country, especially in the wood pulp industry. Of the richer pyrites there is extracted something more than 2000 tons of copper in local converters. At Grong, in the Trondhjem district, near the Swedish frontier, the presence of extensive deposits of iron pyrites, containing copper, is reported.

The production of Sulitjelma in 1912 was as follows: 123,250 tons exported; 14,850 tons smelted; 11,500 tons concentrated by Elmore process.

At the works, 14,400 tons of pyrites and 5750 tons of concentrates have been smelted, producing 1024 tons of Bessemer copper; 2,500 tons of copper concentrates have also been exported.

At the works at Sandras, 290,000 tons of crude ore were passed through the "scheidage"(?) and 190,000 tons were concentrated. The concentrator is being remodeled.

A new furnace to treat the Elmore product has just been finished, and will produce 2000 to 2500 tons of copper. It has been decided to increase the production, to produce about 165,000 tons of pyrites, and the

copper produced to 2500 tons per year. For this also a new washery will be installed near the Tornerkjelm mine.

The Bossmo mines produced as usual 23,500 tons of washed iron pyrites, employing about 200 men.

The Loekken mines (Orkla) produced in 1912 116,000 tons of pyrites, which were exported. It is expected the production in 1913 will be 140,000 tons, although the concentrator was destroyed by fire in 1911.

The mines at Foldal in 1912 produced 72,000 tons of pyrites, employing about 440 men.

The mines at Roestvangen produced about 26,893 tons of pyrites of which 23,896 tons were exported. A concentrator is to be built.

The mines at Roeros, produced in 1912, 11,000 tons of pyrites, which were exported and of which 8300 tons were washed ore, and 2700 tons lump ore.

From Killingdal, 25,000 tons of pyrites were exported and from Stordo, 21,000 tons.

At the mines of Vigtnos, installations are being made to produce 12,000 tons of pyrites per year.

Adding the production of such mines as Savanoe, Fos, Roedpjeld et Kjoeli, the production of pyrites in 1912 is about 430,000 tons, of which 390,000 tons have been exported. The production for 1913 may pass 500,000 tons, according to these increases.

*Russia.*—According to the Russian year book, about 12,000 tons of pyrite are produced in Russia annually, 10,600 tons are reported for 1909 and 12,700 tons for 1910. The principal mines are mentioned in MINERAL INDUSTRY, Vol XX, p. 688.

*Spain and Portugal.*—The pyrite sulphur ores are in part classified as copper ores in the reports of the government, so that it is impossible to make an estimate from these reports.

The following table of shipments from Huelva of copper and iron pyrite indicates the scale of the industry in 1910.

| Shippers. | Cuprous Pyrites. | Iron Pyrites. | Total. |
|---|---|---|---|
| Rio Tinto Company, Ltd. | 596,324 | 694,816 | 1,291,140 |
| Tharsis Sulphur & Copper Mines, Ltd. | 25,149 | 443,065 | 486,214 |
| Societe Francaise des Pyrites de Huelva | 2,469 | 214,641 | 217,140 |
| Pena Copper Mines, Ltd. | 17,399 | 121,422 | 138,821 |
| Esperanza Mining Co, Ltd. | 88,845 | 11,443 | 100,288 |
| Huelva Copper Mines, Ltd. | 12,484 | 2,822 | 15,306 |
| San Miguel Copper & Sulphur Mining, Ltd. | 8,158 | 52,984 | 61,142 |
| Societe des Mines de San Platon | 33,140 | 15,772 | 48,912 |
| United Alkali Co., Ltd. | 73,489 | 56,187 | 129,676 |
| La Hispalense Mine | 7,805 | 342 | 8,147 |
| Hijos de Vazquez Lopez | 345 | 36,712 | 32,057 |
| Societe des Mines de San Pedro | 6,385 | 4,043 | 10,428 |
| C. and J. Sundheim | ..... | 4,929 | 4,929 |
| Other mines | 2,976 | 700 | 3,676 |
| Total | 874,968 | 1,659,908 | 2,534,876 |

The above shipments were made to the following countries:

| | Cuprous Pyrites. | Iron Pyrites. |
|---|---|---|
| Algiers and Natal | ..... | 14,263 |
| Australia | ..... | 15,192 |
| Austria-Hungary | ..... | 24,195 |
| Belgium | 22,845 | 48,314 |
| Denmark | 10,399 | ..... |
| France | 16,243 | 239,842 |
| Germany | 125,885 | 256,409 |
| Netherlands | 236,070 | 171,797 |
| Italy | 2,884 | 65,691 |
| Norway | 1,878 | ..... |
| Portugal | ..... | 9,104 |
| Russia | 204 | 22,154 |
| Spain | 61 | 50,719 |
| Sweden | 5,856 | 17,858 |
| United Kingdom | 221,021 | 278,146 |
| United States | 231,622 | 446,224 |

The pyrites exported from Spain was 2,769,607 tons in 1911, and 2,292,014 tons in 1912.

Rio Tinto, the greatest pyrite mine, is credited with ore reserves of about 60 years, and has produced 1,000,000 tons of copper. The company mined 2,406,969 tons of ore in 1912. Of this 688,861 tons of cupriferous pyrite and 977,812 tons of iron pyrite were sold. The copper sold amounted to 39,925 tons. The net profit is stated as £1,935,000

The production was as follows:

| | 1911. | 1912. |
|---|---|---|
| Pyrites for shipment, tons | 649,215 | 698,399 |
| Ores for treatment, tons | 1,536,390 | 1,708,570 |
| Totals, mined | 2,185,605 | 2,406,969 |

Mining with a view to a later removal of all ore is being continued. Shipping facilities for the increased tonnage are adequate. The water supply for leaching, etc., was carefully handled on account of a shortage in water.

The Pyrites Co., Ltd., the principal handler of Rio Tinto ores in the United States, is preparing a plant at Roanoke, Va., where it will extract copper and prepare cinder near to the fertilizer market of the South.

The total amount of ore produced at Tharsis was 352,281 tons in 1912, as compared with 327,348 tons in 1911. The total shipments were 555,616 tons, as against 481,700 tons in 1911. The pyrite including the washed ore, shipped in 1912, was 543,835 tons, as compared with 477,364 tons in 1911. The copper precipitates increased to 2,408 tons in 1912, as compared with 2,249 tons in 1911. Since March, 1912, a new roasting furnace has been in use at the works at Garngad, and the type of furnace

used is being installed in all the works. The production of the fine copper was 3377 tons in 1912, as compared with 3393 tons in 1911.

*Turkey.*—The last official report of the Department of Mines and Forests of Turkey is for the fiscal year ending March, 1909: in 1908, 58,630 metric tons were produced valued at £36,296; 1909: 78,640 metric tons valued at £51,000.

*United Kingdom.*—The production of pyrite in 1911 was 734 tons valued at £4,237. Nodules are picked out at some of the coal mines. Iron pyrites, chiefly copper-bearing, was imported into the United Kingdom from the following countries:

| | Tons 1910. | Tons 1911 |
|---|---|---|
| Norway | 90,935 | 94,748 |
| France | 47,522 | 32,111 |
| Portugal | 79,383 | 75,731 |
| Spain | 537,972 | 603,621 |
| Newfoundland | 39,008 | 31,050 |
| Other parts | 17,347 | 12,660 |
| Total quantities | 812,247 | 849,941 |

During 1912 the corresponding imports were 907,157 long tons.

The burnt ore treated in Great Britain was chiefly supplied to the Tharsis Sulphur and Copper Co., Ltd., and the United Alkali Co., Ltd. The total burned in 1910 was 433,129 tons; in 1911, 407,838 tons. The estimated copper extracted from this ore was 15,592 tons in 1910, and 14,682 tons in 1911. In addition, in 1911, 1873 oz. of gold and 326,271 oz. of silver were extracted by Claudet's process.

## Technology

*Utilization of Pyrites-Cinder.*—As the tendency is to use all by-products from chemical works or acid producers, the cinder is prepared for the iron blast-furnace in most cases at present by means of the nodulizing process. The sulphur is eliminated at will, while the copper content varies according to the leaching process used and the grade of the original ore. Any objection to residual copper in the cinder appears to be more than balanced by the beneficial effects (as determined by tests at a number of steel works) due to the presence of the copper which goes almost entirely into the iron made. From such tests it is claimed that 0.2 per cent. copper in steel increases its life and protects it from corrosion.

*Use of Substitutes for Pyrite.*—The use of other ores than iron pyrites for sulphur is feasible, especially where the sulphur gases are by-products

and are ordinarily wasted to the injury of the crops, or at least give rise to lawsuits the expense of which can be avoided by proper installation. Such ores are cupriferous pyrite, pyrrhotite and blende.

*Pyrrhotite as Source of Sulphur.*—This ore contains as low as 15 per cent. and, according to the chemical composition $Fe_7S_8$, up to 39.6 per cent.

The lower grade is reached, for example, in the nickeliferous ores of Sudbury, and ores of this character are not usually regarded as sources of sulphur.

While it was formerly considered impracticable to obtain acid from pyrrhotite, the perfection of furnaces for roasting the ore is such that, under some circumstances, it is feasible. Some of these ores will roast pyritically and produce a gas containing 4 per cent. sulphur dioxide.

Mr. E. A. Sjostedt made experiments at Sault Ste. Marie, Ontario, on ores containing 15–20 per cent. sulphur, 1–3 per cent. nickel, 0.5–0.2 per cent. copper.

The ore is sorted into two grades, one high in copper, and the other high in nickel, the latter being used for the acid and containing 28 per cent. sulphur.

The result of the experiments was to build four batteries of kilns, 16 unites, having a total capacity of 40 tons of ore per day. One of the auxiliary plants was a screening plant, and another, used at first, contained gas-generators, making water-gas. The latter was finally dispensed with as the ore was found to be self-roasting, producing a gas containing from 6 to 10 per cent. $SO_2$, as against the theoretical maximum of 12.78 per cent. $SO_2$. The residue ran as low as 0.75 to 0.20 per cent. sulphur, but generally from 1 to 3 per cent. of sulphur remaining, giving a good quality of gas.

The following tables show the hourly tests of gas and the sulphur in the roasted fines.

ROASTING RESULTS (AVERAGE RESULTS OF TESTS MADE EACH HOUR).

| February | 11–12. | 13–14. | 15–16. | 17–18. | 19–20. | 21–22. | 23–24. |
|---|---|---|---|---|---|---|---|
| Strength of gas, per cent. $SO_2$ | 8.60 | 8.30 | 7.90 | 7.40 | 7.40 | 7.60 | 7.70 |
| Roasted fines, per cent. S | 1.66 | 1.86 | 2.04 | 2.54 | 1.78 | 0.95 | 1.86 |

The average per cent. of sulphur in the ore was 24.46.

At first only pyrrhotite was used for acid-making, but pyrites is now available and altogether 10,000 tons of pyrrhotite had been roasted in these kilns.

The discussion of costs, comparing pyrite with sulphur, was given in

Sjostedt's report; also *Eng. and Min. Journ.*, Vol. LXXXI, 1906, p. 803 Also F. J. Falding, in reference to New England sections.[1]

*Pyrite Substitute for Sulphur.*—The use of sulphur at pulp mills for sulphurous acid is, of course, the general practice, but the production of sulphurous acid is accomplished economically at some of the pulp mills in Scandinavia and Germany. In Canada one mill is projected to work on this plan.

*Concentration.*—The flow sheets for concentration of pyrites at the Cole mine, St. Lawrence County, N. Y., at the Eustis Mining Company, and at the St. Lawrence Pyrites Company, are given in the report on "Pyrites in Canada."[2]

*Analysis.*—The importance of eliminating alkaline salts such as are formed in precipitating iron, is brought out in a paper on Determining Sulphur in Pyrites.[3] The method has been found reliable and is used in the laboratory of the General Chemical Co. The iron is reduced with powdered aluminium and the precipitant $BaCl_2$ added by a special form of precipitating cup. The new method now also adopted by the various analysts in New York has been found to give results about 0.1 to 0.15 per cent. higher than the ordinary methods. Check determinations agree to a few hundredths of 1 per cent. S.

The determination of sulphur in pyrite by a new exact electrochemical method is discussed by Albert M. Smoot.[4] The heavy metals are removed by electrolysis from the solution leaving a solution of the sulphuric acid to work with.

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[1] *Journal Soc. Chem. Ind.*, May, 1906, Vol. XXV.
[2] Alfred W. G. Wilson, Ph. D., Department of Mines, Canada, 1912, p. 34.
[3] W. S. Allen and Howard B. Bishop, *Eighth International Congress Applied Chemistry.*
[4] *Eng. Min. Journ.*, Vol. XCIV, No. 9, p. 412.

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## SULPHURIC ACID.

The total production of sulphuric acid of all grades in the United States during 1912 was 3,462,000 long tons figured at 50° Bé., as against approximately 3,250,000 tons in 1911. About three-quarters of the eastern production are used in the manufacture of fertilizer, about 10 per cent. in the refining of petroleum products and the remainder is about equally divided between the iron, steel and coke industry, the manufacture of high explosives, celluloid, etc., and the general chemical industries.

The three important commercial grades of acid are: first, 50° Bé. or chamber acid containing 62.18 per cent. of $H_2SO_4$ and of 1.526 sp. gr.; second 60° Bé. acid 77.67 per cent. $H_2SO_4$ of 1.706 sp. gr.; and third, 66° Bé. acid or oil of vitriol (93.19 per cent. $H_2SO_4$) of 1.835 sp. gr. Of these three grades the first is the most important as all the acid used in the manufacture of fertilizer is of this class. It may vary commercially from 49° to 54° Bé. In addition to these are the special grades of oleum and fuming acid containing free $SO_3$.

The sources of production of sulphuric acid in the United States during 1912 in the 50° Bé. equivalent were:

| | |
|---|---|
| From pyrite domestic and imported | 2,839,360 long tons |
| From zinc ores | 292,748 long tons |
| From copper ores | (e) 270,000 long tons |
| From brimstone | (e) 60,000 long tons |
| | 3,462,108 long tons |

(e) Estimated.

From the above it will be seen that over 15 per cent. of the total is by-product acid.

The spelter acid production of the United States in short tons figured at 60° Bé. during the past three years was:

| | |
|---|---|
| 1910 | 207,000 tons |
| 1911 | 256,192 tons |
| 1912 | 262,555 tons |

The acid production at copper smelteries was:

| | |
|---|---|
| 1910 | |
| 1911 | 258,000 |
| 1912 | 300,000 |

The report of the Tennessee Copper Co. for 1912 states that 192,084 tons of acid were produced.

Acid is made from brimstone at several small plants on the Atlantic coast and by one steel company it is most extensively made from imported sulphur on the Pacific coast and at one or two Gulf-oil refineries.

The growing effectiveness of the contact process producing high-grade acid is making the more expensive brimstone unnecessary and it will probably in the not distant future be so used only under special local conditions.

*Markets.*—The acid business as a whole increased but with declining prices during 1912. The large increase in by-product acid from Tennessee coming simultaneously with an unfavorable agricultural season, had a depressive effect on the industry throughout the southeastern states. The middle west was unaffected while some decline was noted on the Pacific coast. Acid was quoted at $5.20 for 50° Bé. acid per ton.

*Australia.*—The 1911 annual report of the Wallaroo & Moonta Mining & Smelting Co., situated at Port Wallaroo, South Australia, states that since the company has installed a converter plant it has been of no advantage, in blast-furnace treatment, to have the ores treated in the pyrites burners. The entire charge of operating the burners has, therefore, been charged against the production of sulphuric acid. During 1911 the plant operated 44 weeks and produced 4627 tons of acid, or an average of 105 tons per week. Extensive repairs were made which interrupted operations for nearly 8 weeks; the cost of this work is included in the cost of producing 1 long ton of sulphuric acid at this plant during 1911: making a total of $5.55 per ton. The average price received from the sale of sulphuric acid, which is bought by the Wallaroo Phosphate Co., was about $7.39 per ton, indicating that the profits averaged $1.84 per ton of acid.

*Belgium.*—The factories manufacturing sulphuric acid in Belgium are 57 in number. Some of these use the acid as a raw material producing sulphate and superphosphate. Twenty-six of these factories are direct producers of acid. Sixteen of them produce superphosphate; the total volume of lead chambers in use is about 400,000 cubic meters, but the

annual production of the works is less than the theoretical capacity, varying from 300,000 to 320,000 tons of acid of 60° Bé. The raw materials used are zinc blende and iron pyrites, the latter chiefly from Spain, Portugal and occasionally from Japan. Copper pyrites is also used from Portugal and Norway; the 2 to 3 1/2 per cent. copper being extracted by wet methods. The zinc blende is largely imported from Algeria, France, and Germany. The Algerian ore is totally free from arsenic. The charge for roasting zinc blende is usually $1.55 per ton plus transportation.

The largest unit in operation is 282,000 cu. ft. of chambers. Three of the acid workers use Moritz chambers. They are the Société Anonyme des Superphosphates et Guanos, at Ghent (140,000 cu. ft.); the Société Anonyme des Industries Chimiques de Wisèle (265,000 cu. ft.); and the Rosier Campagnie, at Moustier (282,000 cu. ft). The method has been found to be satisfactory and there is less depreciation and less consumption of nitric acid, and less space involved. The Delplace automatic meter for controlling the volume of acid distributed to the Glover towers is much used in Belgium. For concentration on account of the expense of platinum, porcelain basins are much used, or these are lately being replaced with basins of fused quartz. For this purpose these basins are made with a diameter of 12.2 in., and a depth of 5.1 in. Another substance used for basins is the so-called neutral iron. This is a combination of iron and silicon, unaffected by boiling sulphuric acid. The material is, however, difficult to work. The Kessler apparatus for evaporating is also used where purity is not essential. This consists essentially of a shallow vat of sand-stone enclosed in lead. Hot gases from a coke furnace produce a rapid evaporation, and a series of partitions above the surface of the acid, cause the gas current to pass back and forth several times until it reaches the regenerator above. In this there are perforated plates of lava, over which weak acid trickles on its way to the vat. This acid is 57 per cent. B, and it is concentrated to 66 per cent. The gases then pass through a coke tower, acting as a filter; the weak acid from which (15 to 30° B.) is used for leaching copper ores. Another apparatus recently replacing the Kessler evaporator is the Gaillard tower, now supposed to be the best device for concentration on a large scale. The tower is constructed of lava, cut in the form of rings, cemented upon one another by a mixture of ground lava and water glass. The diameter is 7 ft. and the height usually 50 ft. The concentration is said to take place easily; the 66° acid being collected at the bottom in cooling pipes. The total sulphuric acid exported in 1911, to Germany, was 89,000 tons. Two-thirds of this production is consumed in the superphosphate industry in that country.

In Belgium there are 13 factories engaged in the manufacture of nitric acid, and the bulk of the product is used in connection with other operations at these factories. Most of the acid is of 36° strength, but some 45 and 48° is prepared for the artificial silk and high explosives industries. The annual production is 11,000 tons of 36° acid. 2,000 tons of this are exported to France.

The sulphuric-acid industry, as well as some other chemical industries of Belgium, are controlled by the Union Commerciale, since 1890, and this has prevented any serious crises due to overproduction of low prices.[1]

Sulphurous Acid.—A factory near Liege, Belgium, makes a specialty of liquid sulphur dioxide, furnishing about 80 tons per annum. One-half of this is exported. There is a growing tendency to substitute this chemical for sulphites and bi-sulphites, in bleaching operations.

*Canada.*—Brimstone acid is made at the Dominion Iron & Steel Co.'s works, Sydney, Cape Breton, Nova Scotia, and at the Victoria Chemical Co., Victoria, B. C.; the former plant is of 50-ton capacity per day (50° B. acid) and uses Louisiana sulphur. The latter plant uses Japanese sulphur. Other producers of sulphuric acid are the Capleton works, Quebec, and Sulphide, Ontario, and the Barnet Bay works, B. C., of the Nichols Chemical Co.; the Hamilton, Ontario works of the Grasselli Chemical Co. and the Lake Superior Corporation, Sault Ste Marie, Ont. The last two recently built will use pyrites to a large extent.

As to sulphuric acid, the amount produced is limited, and only small quantities are imported, so that nearly all acid required is supplied by the domestic market. Many chemicals are imported into Canada, however, which require the treatment with sulphuric acid, but are now manufactured in foreign countries. The increased use in artificial fertilizers also tends to increase the market for sulphuric acid.

SULPHURIC ACID ENTERED FOR CONSUMPTION IN CANADA, 1885-1912.

| Fiscal Year Ends March 31. | Quantity in Pounds. | Value $ | Fiscal Year. | Quantity in Pounds. | Value $. |
|---|---|---|---|---|---|
| 1885 | 774,764 | 10,791 | 1899 | 165,637 | 2,427 |
| 1886 | 507,927 | 7,930 | 1900 | 740,858 | 7,066 |
| 1887 | 678,603 | 8,468 | 1901 | 448,608 | 5,272 |
| 1888 | 2,494,648 | 35,415 | 1902 | 420,731 | 4,626 |
| 1889 | 181,652 | 2,606 | 1903 | 102,314 | 2,332 |
| 1890 | 211,871 | 2,927 | 1904 | 113,407 | 2,563 |
| 1891 | 177,627 | 2,466 | 1905 | 920,804 | 8,227 |
| 1892 | 222,623 | 2,837 | 1906 | (a)822,585 | 8,558 |
| 1893 | 172,422 | 2,367 | 1907 | (b)733,151 | 6,901 |
| 1894 | 107,520 | 1,648 | 1908 | (c)650,095 | 7,582 |
| 1895 | 174,605 | 2,481 | 1909 | 241,388 | 3,298 |
| 1896 | 114,137 | 1,430 | 1910 | 914,058 | 8,466 |
| 1897 | 977,446 | 8,033 | 1911 | 2,486,992 | 21,855 |
| 1898 | 665,344 | 5,536 | 1912 | 1,615,180 | 15,027 |

(a) For 12 months ending June 30.
(b) For 9 months ending March 31.
(c) For 12 months ending March 31.

[1] Cons. Reprt, Series No. 65.

*Germany.*—The sulphuric acid produced in Bavaria in 1910 amounted to 171,132 tons, valued at 6,492,120 marks. In 1911, the sulphuric acid produced amounted to 170,039 tons, valued at 6,346,360 marks. In this industry 370 workmen were employed.

The Dwight Lloyd machine is used in connection with sulphuric acid manufactured in Germany,[1] but not in the United States.

*Netherlands.*—Although originally the domestic supply from G. F. Ketjen & Co. was insufficient, exports are now being made to the Dutch Colonies and to Scandinavia. Two factories of this company make ordinary chamber acid in one, and fuming acid by the contact process in the other. 12,200 metric tons of sulphuric acid was annually imported but probably much of this is re-exported. The pyrites used is from Spain.

*Russia.*—Sulphuric acid in one of the leading chemicals produced in Russia, although for fertilizer purposes it has been largely imported. Pyrite deposits are used in the Urals, while phosphates are manufactured in many localities. Large amounts of pyrite are also imported. The Russian pyrite used in 1911 for acid is estimated at 3,000,000 poods or 50,000 tons. The Kyshtim corporation intends to build a plant producing 1000 tons of acid per day.

## Sulphuric Acid Technology

The predominant importance of pyrite acid manufacture makes the utilization of the cinder residue an economic factor. Pure pyrite is readily burned in the acid plant to between 1 and 2 per cent. sulphur, pyrite to be subsequently leached for copper is burned to from 3 to 5 per cent. sulphur. To prepare the cinder for use as an iron ore it must be further desulphurized and nodulized. In the nodulizing process the sulphur may be removed almost at will. The case of nodulizing depends on the physical character of the original ore, and the cost may vary from 40 cents to over $1.25 per ton. Nodulizing is regularly practiced in Pennsylvania and adjacent states, but in the South the cinder is still unmarketed.

All but 35,000 to 40,000 tons of the phosphate rock consumed in the United States was acid treated in 1912. It requires 1 ton of 50° B acid to treat 1 ton of phosphate. Acid producers are much interested in the development of the Newberry Fishburne calcining process for phosphates and its possible effect on the acid trade. Other developments, however, notably the manufacture of ammonia sulphate at by-product coke plants and the manufacture of alum from bauxite, offer prospective large markets.

[1] Manufacture of Sulphuric Acid, M. Hasenclever, *Eng. and Min. Journ.*, Jan. 20, 1913.

*Sulphuric Acid From Brimstone.*—A small pyritic acid plant in operation at the United States Naval Proving Ground, Indian Head, Md., since 1907, making acid for smokeless powder was 2 years ago converted to a brimstone plant using Louisiana brimstone with a Tromblee and Paull burner and the contact process. The charge was reported to be successful and to produce more economically than with pyrite.[1]

There are numerous idle brimstone burners in the Eastern states, and, as previously noted, unless there is a marked change in the relative cost of brimstone versus pyrite sulphur, brimstone will be used for acid only under experimental conditions.

*Combined Chamber and Contact Process.*—A system of combining the chamber process with the contact process has proven successful.[2]

The contact process has been usually considered as a competitor of the older systems. A plant having an installation of the contact process (licensed under United States patents of the Verein Chemischer Fabriken Mannheim) and producing strong acid) was modified by adding the chamber process. The problem involved the manufacture of various grades of acid and considered costs of installation and manufacture and the market for the chamber acid.

The burning capacity adopted was for both fines and lump, 24,000 lb. fines and 36,000 lb. lump per day. Thirty-six lump burners and four standard Herreschoff fines burners were installed. The iron oxide contact shaft received the combined gases, an exhaust fan being used after the fines burners and another fan between the shaft and the Glover Tower. The conversion here was about 30 per cent. The gases were then forced into the chamber system It was found that the result can be summarized as follows: The capacity of the chamber plant was increased at least 30 per cent. The contact shaft conversion ($SO_2$ to $SO_3$ was 30 per cent. The Glover Tower produced water white acid. 95 per cent. of the As in the gases was eliminated in the contact with iron oxide.

The total chamber acid produced could be easily concentrated to 60° B. in the Glover tower.

The iron oxide contact shaft acts as a dust catcher and equalizer of heat and saves 30 per cent. of the nitre consumed ordinarily.

*Concentrating Sulphurous Gases.*—A process for concentrating sulphur dioxide in furnace gases[3] uses a tower with baffle pans and broken stone for decending water, a bottom inlet, and side and top outlets for gases. The gases from the top are claimed to be almost freed from sul-

[1] Contact Sulphuric Acid from Brimstone, S. W. Patterson and Q. B. Chaney, *Eighth Intl. Cong. Appl. Chemistry.*
[2] Wm Wilke, Buffalo, N. Y., *Eighth Intl. Cong. of Appl. Chem.*
[3] United States Patent 1046915 to Utley Wedge.

phur dioxide by the cool incoming water, while those from the side outlet are enriched by that liberated in the heated filter bed.

*Dwight and Lloyd Process in Acid-burning.*—As elsewhere noted, the Dwight and Lloyd sintering process is not used for acid burning in the United States, though it is to a limited extent in Germany.

Gas analyses made at some of the Dwight and Lloyd plants in the United States from samples taken under normal running conditions, with no attempt to obtain a rich gas, are as follows:

| | $SO_2$ | | $SO_2$ | | |
|---|---|---|---|---|---|
| 1. | 1.82 | | 1.37 | | |
| 2. | 4.5 | | 0.03 | | |
| 3. | 6.6 | | 0.1 | | |
| | | $(CO_2)$ | | $(O_2)$ | N |
| Typical average analysis: | 3.6 | 1.2 | | 15.4 | 78.8 |

Careful experiments have shown that by careful adjustment a gas averaging 4 per cent. $SO_2$ can generally be obtained, while by selecting the gas from the most active portion of the charges 6 per cent. $SO_2$ is perfectly feasible.

The process of treatment of sulphides under certain conditions can be made to eliminate a considerable portion of the sulphur as elemental sulphur, though just how far this can be carried has not yet been definitely determined on a full working scale. It offers, however, a very attractive field for future development.

The Dwight and Lloyd principles have now been successfully adapted to the agglomeration of finely divided iron ores, pyrites cinder, etc.

According to Mr. Dwight, fine pyrites cinder is easily converted by the Dwight and Lloyd process into an admirable product for the iron furnaces by sintering with about 7 per cent. of carbonaceous material (coke dust or fine coal) and in the process the residual sulphur is reduced from, say, 1.5 per cent. to 0.04 per cent.

*The Falding Acid Chamber.*—Much has been written recently regarding the advantages of this system of high chambers.

The theory of the high chamber is that the hot reacting gases are at the top of the chamber while the gases which have reacted and cooled sink to the bottom and are drawn off from there into the next chamber. That this separation may be as complete as possible, the height of the chamber is increased, and the base is square instead of a rectangle. Advantages claimed for the high chamber are:

(1) Saving of lead. This is from 35 to 50 per cent. for equal cubic capacity, making no allowance for the greater efficiency of the higher chamber space.

(2) Greater efficiency of the high chamber space. Six to 7 cu. ft. of chamber space per pound of sulphur burned without the assistance of any auxiliary apparatus, such as surface condensers.

(3) Great economy of ground area and foundations. Requires from one-third to one-half as much ground space as the old systems.

(4) Fire-proof and storm-proof construction. The construction of buildings and chamber supports is of steel and concrete.

(5) Economy of labor. A plant with a capacity up to 100 tons per day of 66° B. acid requires, with fine pyrites, 5 to 6 men in 24 hours.

A description of these plants and their construction is detailed.[1]

The economic success of this system is still, however, questioned by many because of the serious cost of maintenance. The Tennessee Copper Co. plant at Copperhill, Tenn., the United States Steel plant at Vandergrift, Pa., the Cleveland Cliff Co. plant at Marquette, Mich., and two other plants in Canada are the notable Falding installations.

*Opl Acid Towers.*—The acid plant at Hruschau, Austria, where the Opl towers were first put into use, is gradually scrapping its chamber plant, and replacing it by towers, as about double production can be obtained on the same ground area.[2] In a plant for the production of 18 tons of 142° Tw. acid per day, six packed towers are used, the first acting as Glovers, the last as Gay-Lussacs. The last towers produce an acid rich in nitric, which runs down the Glover with the total production, the acid running off being 142° Tw., and practically free from niter.

A coke chest behind the sixth tower retains the uncondensed acid fumes, the exit gases carrying from 0.4 to 0.65 grm. $SO_3$ per cubic foot. For an 18-ton plant, a content of 21,180 cu. ft. is needed, *i.e.*, the production is 1.87 lb. $H_2SO_4$ (142° Tw.) per cubic foot, or 2.04 cu. ft. of tower are required per pound of sulphur per 24 hours. A fan at the end of the system produces the necessary draft.

The advantages of the Opl are said to be: (1) Lower initial cost; (2) less ground space; (3) easier supervision; total production at 142° Tw. even with mechanical roasters. The entire process is controlled by an operator on a platform who constantly takes samples of the circulating acids from a receiver in front of him, and by the results moves the valves controlling the water sprays and acid pumps.

*Construction of Lead Chamber Walls.*—The structural properties of sheet lead are poor and great care is required in designing, to insure that the lead is subject only to simple stresses of small magnitude.[3] In constructing lead chamber walls Awe recommends a horizontal suspension of the sheets. The carriers consist of horizontal angle irons, over which is laid a lead angle or the bent-over edge of the lead sheet. This is clamped to the angle iron by means of a strip of flat iron with bolts, and the joint made by soldering in the usual manner. As-

[1] *Eng. and Min. Journ.*, Feb. 8, 1913, p. 318.
[2] *Chem. Trade Journ.*, Jan. 25, 1913; and *Eng. and Min. Journ.*, Feb. 15, 1913.
[3] *Zeit. angew. Chem.*, 1912, p. 2523; abstr. *Journ. Soc. Chem. Ind.*, Jan. 15, 1913, p. 21.

suming that the thickness of the lead is 3 mm. and that the horizontal angle irons are 1.5 m. apart, the lead having a specific gravity of 11.3, then the tensional stresses in the lead are only about 2 kg. per square centimeter. No other stresses occur, since the attachment to the angle irons is uniform. The distance between the vertical supports of the angle irons may be fixed at will, the only condition being the absence of sagging. With light angle irons the supports may be 3.75 to 4.25 m. apart and thus a space of approximately 6 sq. m. is left clear for repairs. On the other hand, the use of vertical carriers for the lead sheets sets up large and not readily calculated stresses, the carriers must be set closely together to counteract the tendency for the lead to give way at the seams, and this allows little space for repairs.

*Thiogen Process.*—The experiments conducted at the Penn smeltery, Campo Seco, Calif., are described by S. W. Young.[1] Many of the early difficulties have been eliminated. The theory of the process involves the production of elemental sulphur by reducing the smelter fumes with hydrocarbon vapor, and as a catalytic mixture, calcium sulphite and calcium sulphide. The poisoning of the contact mass was a chief trouble. Exit gases, however, containing practically no sulphur-dioxide, have been maintained during 10 and 12 day runs. The ultimate success of the process, in the opinion of those interested, seems assured, and its difficulties are being removed.

An apparatus for determining the action of this process, as used by Prof. Young in laboratory tests, is described.[2]

*Consumption of Sulphuric Acid.*—The great interest shown in the Newberry-Fishburne calcined-phosphate process led many to believe that its effects on the acid trade of the United States may be considerable. If, however, the consumption be decreased in this direction, it is quite as likely that an increase will take place in the consumption for making ammonium sulphate at the regenerative coke ovens. It may be that the large proportion of the sulphuric acid consumption, therefore, will remain with the fertilizer industry.

*Sulphuric Dioxide.*—It is estimated by C. M. Bullard that 1,500,000 tons sulphur are consumed every 24 hours in the sulphite mills in America. This is based on the 280 lb. of sulphur per ton of product. The cost of sulphite pulp in one Canadian mill averages in recent years $2.72 for sulphur. In the United States this cost is higher, being reported[3] as $3.01 in 1909. A comparative estimate of cost for sulphur for a 100-ton sulphite pulp plant,[4] is as follows: Based on 250 lb. per ton of

[1] Prof. of Physical Chemistry, Stanford University, Calif. *Eng. and Min. Journ.*, Feb. 15, 1913.
[2] *Eng. and Min. Journ.*, Sept. 7, 1912, p. 445.
[3] Tariff Board Report, Senate Document 31, pp. 82 and 84, Washington, 1911.
[4] A. W. G. Wilson, Ph. D., Pyrites, Department of Mines, Canada, 1912.

pulp produced, allowing 10 per cent. depreciation on cost of equipment, namely on $10,500, the sulphur cost per ton is figured at $2.95. Using 45 per cent. pyrites allowing for 2 per cent. loss in roasting, a cost of $6 per ton of pyrites depreciation on $66,500, repairs, power, etc., the cost figures $2.15 per ton. Using 35 per cent. pyrites assuming a roasting loss of 2 per cent., a cost of ore $4.90, a depreciation on $68,700, labor, etc., the cost figures $2.38.

*Analysis.*—F. G. Hawley has described a new method by determining $SO_3$ in flue gases. The Hempel method, like indirect methods, is likely to give considerable error as the total sulphur is generally much higher than the sulphur in the $SO_3$. $CO_2$ bars the use of phenolphthalein indicators as used in Lunge. The new method is based on the fact that $SO_3$ is a solid which can be filtered out. In practice, a damp paper filter is not decomposed before determining the $So_3$.

$SO_3$ occurs in two forms, having different melting-points, but the same molecular weight (80). The melting-points are 62.2 F. and 112.8 F.[1]

Diphenylamine may be used[2] to determine the $SO_3$ in fuming acid, as it gives a pink to blue coloration. To test any acid containing 30 per cent. or over of $SO_3$ for nitric acid, it should be diluted with about twice its volume of pure sulphuric acid, specific gravity 1.84.

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[1] D. M. Lichty, *Journ. Am. Chem. Soc.*, Nov., 1912.
[2] W. N. Iwano, *Journ. Soc. Chem. Ind.*, Nov. 15, 1912.

# TALC AND SOAPSTONE

The talc industry of the United States was prosperous in 1912, but was not able to supply enough of the finer grades to meet the demand. Imports of such grades amounted to more than 10,000 tons, chiefly from France and Italy. The consumption of talc expanded and toward the end of the year was particularly good.

The production of talc and soapstone was reported by the United States Geological Survey as 159,270 short tons valued $1,706,963 in 1912, as compared with 143,551 short tons, valued $1,646,018 in 1911. New York is the first producer with Vermont second, while Virginia is third. The latter State has only a small output of talc, the chief output being soapstone slabs the value of which far exceeds that of talc.

Prices for ground domestic talc vary from $5 to $13 per ton, according to quality. For imported talc prices range from $13 to $25, the best French averaging about $18 and the Italian about $25.

STATISTICS OF TALC AND SOAPSTONE IN THE UNITED STATES. (*a*)
(In tons of 2000 lb.)

| Year. | Production. | | | | | | Imports. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Fibrous Talc. | | | Talc and Soapstone (*b*). | | | | | |
| | Tons. | Value. | Per Ton. | Tons. | Value. | Per Ton. | Tons. | Value. | Value Per Ton. |
| 1898... | 54,807 | $285,759 | $5.21 | 27,974 | $237,280 | $8.48 | 445 | $5,526 | $10.70 |
| 1899... | 57,120 | 272,595 | 4.77 | 26,682 | 241,267 | 9.04 | 254 | 3,534 | 13.91 |
| 1900... | 45,000 | 236,250 | 5.25 | 26,726 | 249,777 | 9.35 | 79 | 1,070 | 13.50 |
| 1901... | 69,200 | 483,600 | 6.99 | 28,643 | 424,888 | 14.83 | 2,386 | 27,015 | 11.32 |
| 1902... | 71,100 | 615,350 | 8.65 | 26,854 | 525,157 | 19.36 | 2,859 | 35,336 | 12.36 |
| 1903... | 60,230 | 421,600 | 7.00 | 26,671 | 418,460 | 15.69 | 1,791 | 19,677 | 10.99 |
| 1904... | 65,000 | 455,000 | 7.00 | 27,184 | 433,331 | 15.94 | 3,268 | 36,370 | 11.13 |
| 1905... | 67,000 | 519,250 | 7.75 | 40,134 | 637,062 | 15.87 | 4,000 | 48,225 | 12.06 |
| 1906... | 64,200 | 541,600 | 8.43 | 58,972 | 874,356 | 14.82 | 5,643 | 67,818 | 12.02 |
| 1907... | 59,000 | 501,500 | 8.50 | 72,010 | 905,047 | 12.57 | 10,060 | 126,391 | 12.56 |
| 1908... | 70,739 | 697,390 | 9.86 | 46,615 | 703,832 | 15.01 | 7,429 | 97,096 | 13.07 |
| 1909... | 48,536 | 359,957 | 7.42 | 81,802 | 862,002 | 10.53 | 4,417 | 56,287 | 12.74 |
| 1910... | 71,710 | 728,180 | 10.15 | 79,006 | 864,213 | 10.94 | 8,378 | 106,460 | 12.71 |
| 1911... | 62,500(*c*) | 562,500 | 9.00 | 81,521 | 1,032,732 | 12.66 | 7,113 | 88,050 | 12.38 |
| 1912... | 70,000(*c*) | 665,000 | 9.50 | 69,270 | 1,042,000 | 15.03 | 10,989 | 122,956 | 11.19 |

(*a*) Statistics for 1902 and subsequent years are as reported by the United States Geological Survey, except that fibrous talc is as reported by the New York State Geological Survey. (*b*) The value of these products has not much significance owing to the diverse conditions of the material reported. (*c*) Estimated.

*New York* (By D. H. Newland).—Operations in the Gouverneur talc district last year were on the usual scale. The demand for the fibrous talc produced there shows little tendency to fluctuate, but the annual

product may vary somewhat in response to the conditions, favorable or otherwise, for grinding, as practically all of the mills are run by water power derived from the Oswegatchie river. The past season for grinding was perhaps better than the average. The list of active mining companies was increased by the entrance of the Standard Talc Co. into the district, but no new mines were developed. This company made shipments from the old United States property which had been held under lease for some time by the International Pulp Co., but which had reverted to the owner in the preceding year. The Standard Talc Co. shipped the crude rock which was ground at Perth Amboy, N. J. The Uniform Fibrous Talc Co., started operations in 1911, enlarged its milling plant and continued the development of the new mine near Talcville. The International Pulp Co. maintained active operations on the Wight property in the southwestern part of the district and also worked some of its mines near Talcville. Most of its product was ground at Hailesboro, where it has concentrated its milling operations. The Ontario Talc Co., with mine and mill near Fullerville, contributed its normal output.

Outside of the Gouverneur district, the only locality in the State where talc was mined was at Natural Bridge, Lewis County, an occurrence that has only recently attracted attention. The St. Lawrence Talc Co. completed its new mill there and entered the market with its ground product, which is reported to have met with favor among paper manufacturers. The character of the talc and the conditions surrounding its occurrence are quite different than those of the Gouverneur talc. The mineral in its natural state shows no fiber, but is of compact or granular structure. In appearance, some of it resembles massive or vein serpentine, having a translucent pale green color and similar hardness. Analyses show it to possess a variable composition which differs essentially from that of talc. The ground product, however, has a smooth feel, white color and other qualities that make it valuable for filling paper and the company intends to specialize in that trade.

*Vermont.*—Vermont is second among the states in the production of talc and soapstone. During the past 2 years the production has increased nearly 50 per cent. This increase has been mostly in talc. Of these two materials about 30,000 tons are sold annually. The value is over $200,000 annually. Soapstone is mined by the Union Soapstone Co. at Chester Depot and by the Vermont Soapstone Co. at Perkinsville. Talc is mined in a large number of places. The American Quarry Co. mined a good deal of talc at Moretown for several years, but because of litigation the plant is at present shut down. The Eastern Talc Co. at East Granville is doing an active business grinding 20–30 tons daily. Two mines are worked in Rochester, the Williams mine and the Greely

mine. The talc is both foliated and massive and much of it is of excellent quality. A large quantity of talc is ground in an up-to-date mill at the Williams mine, which is now 350 ft. deep. The American Soapstone Finish Co. at Chester Depot, and the Vermont Talc and Soapstone Co. at Windham, also grind a considerable quantity of talc. There is a large deposit of talc at Hammondsville and a mill has been built, but nothing is at present being done there. A large deposit hitherto unworked is now being developed near Waterbury and a mill for grinding has just been put up and the company owning the mine has capital and energy and expects to work the deposit vigorously as soon as the machinery ordered is ready for use.

At Johnson the American Mineral Co. have been getting out 20–25 tons daily. The talc is foliated and of excellent quality. The American Mineral Company of Johnson, Vt., advertised the following analysis: MgO, 28.6 per cent.; $SiO_2$, 53.7 per cent.; $Al_2O_3$, 12.3 per cent.; FeO, 0.9 per cent.; volatile, 4.5 per cent. The capacity of this company's mill is 25 to 30 tons of high slip talc per day.

*Other States.*—In California the production in 1911 from four producers, increased to 1200 short tons of ground product. The demand for this talc was not very great. The talc belt is in San Bernardino County. The talc produced in Georgia, is sawed or turned into pencils or pulverized mainly for foundry facing. Details of chief producers are given by Otto Veatch.[1]

In Massachusetts, the only productive locality was near Zoar. The production of the state decreased largely on account of the fire which destroyed the new talc mill at this place. The talc region of Pennsylvania and New Jersey is in the vicinity of Easton. The production of three producers decreased in 1912. The production in North Carolina is from two localities, one in the western and one in the eastern part of the state, and was about the same in the last two years. The pyrophyllite from the eastern part of the State, is used for pencils which manufacture increase the value of the material. The talc production in Virginia, is recorded as 3255 tons valued at $17,168. The soapstone produced in 1912, was 22,058 tons valued at $559,287. In 1912 there were seven producers. The Virginia Soapstane Company supplies two mills from its quarry, which is now the fifth pit along the strike of the deposit. The grain of the rock dips to the southeast with much regularity, for a distance of 25 miles. The Phoenix Piedmont quarries in Nelson County are near the south end of the soapstone quarry belt. Each quarry has its mill, but railroad facilities are not as good as in the older developments farther north.

[1] Mineral Resources of Ga., *Bull.* No. 23; *Ga. Geol. Surv.*, p. 187, 1910.

In Arkansas operations have been limited by lack of transportation. The deposits occur concentrated within a few square miles in Saline County, and are of good quality. The Arkansas Soapstone and Refractories Manufacturing Company, did not operate in 1912. It is desirable that capital be raised to build a railroad for this property and others, for a distance of 100 miles.

In Texas the talc deposits east of Cedar Mountain, have not been prospected. Two shafts and a cross-cut in one property have not revealed the extent of the deposit, which is a few hundred feet from the Houston Texas Central Railroad. The mass of soapstone is stated by one engineer, to be about 20×90×25 ft.

## Talc in Foreign Countries

The chief resources of talc in Europe are the French Pyrenees and the Italian Alps. Canada is shipping talc to the United States, most of it in the crude form. The talc imported into the United States in general, is in the form of rough rock, powdered talc, soapstone slabs for use in plumbing work, and blocks for making gas tips and other small articles of manufacture. Limited talc operations are conducted in Brazil, in China, in Japan, in India, and Australia.

In Austria most of the talc comes from Styria, and a good deal of it is exported to Germany for paper-making. The leading producers and their outputs are given in Vol. XX, Mineral Industry, p. 700. Very little of this talc goes to the United States.

In Australia according to the report of W. H. Ferguson, Geological Survey of the Victoria mines department, steatite or soapstone outcrops are located 9 miles from Heathcote. Another talcose material, selwynite, is found at the site of the old copper mine, 3 miles north of Heathcote. All of the talc in this locality would be for grinding.

In Canada, the production of soapstone and talc has increased, and in 1912 was 8270 short tons valued at $23,132.

The principal talc deposit operated at present in Canada, is in the township of Huntington, Hastings County, Ontario, and is worked by Cross and Wellington. The product goes to the mill at Madoc, owned by Geo. H. Gillespie & Co., where it is ground and graded according to quality. In 1912 a deposit was opened by the Canadian Talc & Silica Company, Ltd., at Eldorado, and a plant installed. This plant treated 5,404 tons of ground talc, worth $47,725. The value of talc exported from Trenton, Ont., to the United States during the year 1911, was $11,554, and during the year 1912 ,$18,953.

*France.*—The principal deposits are in the Department of Ariège.

It is also mined in other departments of various qualities. The deposits at Luzech are of a bluish-white color, much appreciated in certain trades. The production of talc in France in 1911 was 46,312 tons, valued at 1,584,725 francs at the mines. The corresponding productions in 1910 and 1908, were 38,389 tons and 33,614 tons respectively, valued at 1,286,525 francs and 1,506,775 francs. The figure includes some asbestos.

*Italy.*—Italian talc was in active demand for the extra white grades in the United States; the imports into this country being this same as in previous years. Prices were somewhat increased on account of higher ocean rates, but the industry is on a firm basis. The talc exported to the United States from Leghorn, Italy, in 1910, was $13,703, and in 1911, $6078, as declared through United States consuls. The production in 1911 was 15,620 tons at an average value of $7.13 at the mine. The total exports for Italy for 1912 were 17,182 tons valued 1,030,920 lires; the chief consumer, the U. S., took 4818 tons. Nearly the entire output is ground in eleven establishments, and the best grades exported. The production in 1912 is reported as 12,324 metric tons.

*Other Countries.*—All the talc exported from Mexico in the fiscal year 1912, amounted to 358 tons valued at 150 pesos, and all went to Great Britain. In Norway at the Songefjord, north of Bergen, a mill has been started for grinding talc. Another mill (Norway Talc Mill), has been erected south of Bergen, in Oisteso, Vikor. The production of talc in Spain in 1911, amounted to 5647 tons, valued at 48,712 pesos at the mine.

*Uses and Properties.*—The value of powdered talc is judged by its "feel" or slip. The poorer grades are generally yellowish. The whitest only can be used for toilet powders, for which purpose it has come into extensive use. Some of the best domestic grades are now also used for toilet powders. Powdered talc is used in the manufacture of book and writing-paper, and also for newspaper.[1] It is readily incorporated and its fibrous structure makes it superior to clay on account of strength. Powdered talc is also coming into use for admixture in wall plasters, in waterproof paints, and in steam-pipe coverings. It is also used for foundry facings and facing of rubber moulds, and for the dressing of skins and leathers. For the sizing of cotton cloth, freedom from grit is more essential than any particular color, so as not to dull the cutting knives.

In the form of soapstone, it is used for griddles, hearth stones, gas tips, marking pencils, switchboard panels and other electrical uses. The dielectric strength of soapstone is such that a 1/2-in. slab requires 30,000 to 40,000 volts to penetrate.

[1] Wittel and Welwart-Verwendung und Begutachtung von Talkum in der Papierfabrikation; *Montan. Ztg.*, June 15, 1912, p. 222.

# TIN

The high prices for tin which have now prevailed for some time have stimulated output in all the larger producing countries, and have drawn out larger exports from the Yunnan province of China. They have not, however, developed any important new sources of supply. The yield from Nigeria, from which much was expected, remains small. Tin discoveries are reported from time to time in different countries, but few or none of them seem to reach the point of actual production, and we continue to rely on the old-time producers for our supplies of this metal.

IMPORTS OF TIN INTO THE UNITED STATES.

| Year. | Pounds. | Value. | Year. | Pounds. | Value. | Year. | Pounds. | Value. |
|---|---|---|---|---|---|---|---|---|
| 1902.. | 85,043,353 | $21,263,337 | 1906. | 101,027,188 | $37,446,508 | 1910. | 105,137,740 | $33,921,449 |
| 1903.. | 83,133,847 | 22,265,367 | 1907. | 82,548,838 | 32,075,091 | 1911. | 106,936,872 | 43,390,639 |
| 1904.. | 83,168,657 | 22,356,896 | 1908. | 82,503,190 | 23,932,560 | 1912. | 116,003,385 | 50,371,102 |
| 1905.. | 89,227,698 | 26,316,023 | 1909. | 95,350,020 | 27,559,937 | ..... | ..... | ..... |

*Alaska.*—The York Dredging Co. completed its second season of placer-tin dredging on Buck Creek on October 14, 1912. The dredge was taken out of winter quarters and put in operation on June 29, making the total running time 107 days. The cleanups for the season aggregated 175 tons of cassiterite. The total shipment was 130 tons; the remaining 45 tons ready for shipment were held at York, owing to the wrecking of a gasoline boat plying between York and Nome.

The dredge was installed in September, 1911, and made a 30-day trial run besides the time required in experimenting and adjustment, going into winter quarters on October 15, 1911. The operation in the season of 1912 proved the efficiency of the dredge, which was designed especially for digging stream tin. It is a California-type dredge; the buckets are open-link, 2.75-cu. ft. capacity, and have nickel-steel lips. Manganese-steel lips will be substituted before the dredge begins digging in the season of 1913. The capacity of the dredge is 1200 cu. yd. in 24 hours, but it was found that best results in recovery of the tin were obtained by decreasing the yardage to 950 or 1000 cu. yd. in 24 hours.

The recovery in the season of 1912 was 6.5 lb. of cassiterite per cubic yard of gravel. Higher recoveries have been obtained in the creek, but these came from the center of the stream bed by sluicing methods, while the dredge operation includes the entire width of the channel, from 100

to 160 ft. The cost of placer-tin dredging is greater than for gold dredging, owing to the necessity for more frequent cleanups and the cost, in this instance, of wagon haulage and steamer freight. The production of cassiterite at the rate of 6.5 lb. per cu. yd. requires six to eight cleanups in 24 hours, demanding the labor of three men almost constantly in each of the 12-hour shifts.

The concentrate is transferred from one flume to the bins and there sacked in 50-lb. sacks, while the gravel passing through the screen is delivered to the other flume, so that the bucket line is never idle. The haulage of the product from Buck Creek to tidewater at the town of York costs approximately $14 per ton; water transportation from York to Nome varies from $6 to $10 per ton, depending upon the availability of boats. From Nome to Seattle the rate is $4, and from Seattle to Liverpool $8.50 per ton; a total ordinary rate of $32.50 per ton from the dredging field to Liverpool.

The distance from Buck Creek to York is 14 miles, whence the wagon freight costs about $1 per ton per mile. A six-horse team hauls 5 tons, a four-horse team 3 tons. A traction engine was employed during part of the season of 1912, hauling 7 tons per load, but this method was more expensive than horses and wagons, owing to the fact that the engine wagon could not be loaded to full capacity without cutting the roads into impassable condition. The distance from York to Nome by water is 110 miles, making the freight rate 5.5 cents per mile.

*Secondary Tin in the United States.*—According to statistics of the U. S. Geol. Surv., the secondary tin recovered in 1912 was equal to 26.6 per cent. of the tin, as metal or as oxide, imported into the United States during the year. Secondary tin recoveries increased from 14,706 short tons, valued at $12,353,040, in 1911, to 15,401 tons, valued at $14,301,368, in 1912. The quantity recovered as tin metal in 1912 was 8333 tons and that in alloys and chemical compounds 7068 tons. The value of the recovered tin is based on the yearly average at New York.

The recovered tin includes the tin content of products made from tin scrap by several plants. These included some tin oxide, putty powders, etc., but consisted mainly of tin chloride. As the products are made from scrap tin and thus conserve the primary metal, they are properly regarded as recovered tin. Two forms of tin chloride are handled commercially—stannic and stannous salts. Stannic chloride is usually sold either as a water solution, called bichloride of tin, or as an anhydrous syrupy liquid, termed tetrachloride of tin, and is used principally in the silk industry. Stannous chloride is sold in the form of crystals and is used in dyeing and calico printing.

Most of the tin oxide, tetrachloride, and other products were made from

clean tin-plate clippings or from tin liquors left in dyeing or weighting silks. The dry chlorine process was used to recover the tin from the clippings in some places. In others reverberatory furnaces were used to remove the tin coating, and a large quantity of tin was recovered in the form of a tin powder by the electrolytic treatment of clean scrap, the powder being sent to secondary smelters. The largest recoveries of tin were made from the scruff and drosses that occur in making tin and terne plate, and amounted to over 5000 tons. The recovery of tin from block tin pipe, tin foil, and old tin cans was relatively small. Only one firm reported using old tin containers, from which the tin and solder were first sweated and the black plate remelted to make sash weights. Two years of high prices for tin have failed to bring about any increase in the recovery from used tin cans, and there seems to be no present prospect of any conservation of the large quantity of tin used for tin plate, which now finds its way to the unsightly dump pile.

The principal alloys in which secondary tin was recovered were babbitt and other bearing metals, bronze, solder, pewter, and electrotype metal.

PRODUCTION OF TIN METAL IN THE WORLD.
(In metric tons.)

| Country in which Smelted. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912.] |
|---|---|---|---|---|---|---|
| Australia(*m*) | 7,100 | 6,700 | 6,450 | 5,500 | 5,150 | 5,130 |
| Austria-Hungary(*a*) | 47 | 39 | 52 | 39 | 16 | 14 |
| Banka, sales in Holland (*m*) | 11,440 | 11,710 | 12,150 | 13,631 | 15,147 | 16,111 |
| Billiton, sales in Holland and Java (*m*) | 2,260 | 2,270 | 2,280 | 2,240 | 2,240 | 2,243 |
| Bolivia, metal exported to England(*w*) | 1,143 | 1,174 | 834 | 1,003 | 464 | 552 |
| China, exports(*a*) | 3,728 | 4,836 | 4,516 | 6,510 | 6,056 | 8,785 |
| France(*m*) | *Nil.* | *Nil.* | *Nil.* | *Nil.* | 500 | (*e*)500 |
| Germany, mainly from Bolivian ores(*a*) | 5,838 | 6,374 | 8,995 | 11,394 | 12,426 | (*e*)12,500 |
| Japan(*a*) | 32 | 26 | 23 | 23 | 155 | (*e*)175 |
| Straits Settlements, exports (*m*) | 56,550 | 63,690 | 61,540 | 57,490 | 57,944 | (*e*)61,528 |
| United Kingdom, from domestic ores(*a*) | 4,478 | 5,133 | 5,282 | 4,874 | 4,950 | (*e*)5,061 |
| United Kingdom, from imported ores(*m*) | 10,020 | 11,614 | 11,890 | 13,055 | 13,850 | 13,600 |
| Total production of metal | 102,636 | 113,566 | 114,012 | 115,759 | 118,898 | 126,199 |

(*a*) Official statistics. (*e*) Estimated. (*m*) *Metallgesellschaft.* (*w*) Watson & Co.

NOTE.—Among the more important omissions from the above table, due to imperfect statistics, are the following: (1) Output of native smelters in Central and South Africa; (2) Exports from Siam and the Dutch East Indies to India, China, Korea and Japan; (3) Local consumption in Straits Settlements, Siam and Dutch East Indies.

## TIN MINING IN FOREIGN COUNTRIES

*Africa.*—The productive localities on this continent are in the Belgian Congo, in Nigeria, in Southern Rhodesia, and in the Northern Transvaal; recent discoveries have also been made in Damaraland and in the Cape Colony, and prospecting is to be continued in German East Africa. The last mentioned localities have not yet proved promising.

In the Belgian Congo, anticipating the arrival of the Elisabethville-Bukama railroad in 1915, prospecting work under the auspices of the

Union Minière du Haut-Katanga is to begin at Kansonso. The tin occurs both in pegmatite veins and in placers. A continuation of the Kantanga tin belt has been found by one of the companies at Muika, near Kiambi, on the Luvua. This company, the Thys-Jadot group, is now exploiting some deposits. Tin showings are traced for 2 miles. Ground sluicing is to be started soon, and a 5-stamp mill with tables is to be erected.

Production in Northern Nigeria is steadily increasing, the output coming mainly from alluvial workings; the tin lodes at Jemaa were a failure. The total output of Nigeria in 1912 was 2532 tons of concentrated tin ore, of which 486 came from Maraguta, 384 from Bisichi, 307 from Rayfield, and 312 from Northern Nigeria, Bauchi, etc. The tin locally smelted by the natives of this district is said to be the purest tin in the world (G. T. Holloway, *Transactions* of the Faraday Society, Nov., 1911). The only impurity seems to be a trace of iron.

The Rhodesian government geologist has issued a report on the Victoria tin field, in southeastern Rhodesia. It consists of an area of metamorphic rocks belonging to the epidiorite and banded ironstone groups, bounded on three sides by gray biotite granite. Pegmatite dikes and sills are found along the margins of the granite and are intruded into the metamorphic rocks for some distance. The latter series is more or less altered to greisen and carries much pink and green lithia mica and cassiterite. The former series is unaltered and barren. The whole occurrence is similar to that in the Enterprise district. As regards the tin contents, though blocks of ore weighing 200 lb. have been found, the ore occurrences are patchy and erratic and the average grade is low. The dikes and flat sills average from 6 to 15 ft. in width and hold out possibilities of large low-grade ore-bodies.

Tin mining in the Transvaal showed a slight falling off, with an estimated output of 3135 tons, as compared with 3525 tons in 1911. The higher price obtained in 1912 practically counteracted the loss in production and the value of the yield was £350,000, as against 410,000 in the previous year.

The Zaaiplaats tin mine in the Waterberg district, 175 miles north of Johannesburg, crushed 29,330 short tons of ore, assaying 3.76 per cent. tin during the year 1911–1912. The ore yielded 1647 short tons of concentrate assaying 67 per cent. tin.

A profit of £108,364 resulted. Total dividends from the beginning of operations in 1908 have amounted to £242,351. The fifteen stamps were increased in weight during 1912 from 750 to 1500 lb. each. The ore reserves are 24,622 tons, estimated at 3.42 per cent. tin, with 60,000 tons of 1 to 2 per cent. fine tailings. During 1912 water-shortage at times prevented running more than five stamps. The ore-bodies in this mine

are erratic and similar pipes have become unproductive in the neighboring Groenfontein mine.

The other large Transvaal producer is the Rooiberg mine, working fault fissures and impregnations along joint planes in quartzite overlying granite; further to the east this mine in 1911–1912 milled 20,799 short tons for a yield of 884.58 tons of 67.9 per cent. concentrates, the assay value of the ore treated being 4.94 per cent. Tailings amounting to 44,500 tons, assaying 2.51 per cent. Sn, are now being retreated in a new 15-stamp mill with Cornish tin-dressing appliances. Ore reserves amount to 21,300 tons, assaying 4.7 per cent. Sn. Development work appears so far to have been somewhat disappointing, as no payable ore has been met with in the lowest, the 310-ft. level.

*Australia.*—In the production of tin ore, Tasmania stands first with an output of 3714 long tons of concentrated cassiterite during 1912, followed by Queensland with a production of 3230 long tons, and by New South Wales with a production of 1175 long tons of ore and an additional 900 tons of metallic tin. Western Australia gave 554 long tons of concentrates (£65,159) and Victoria yielded 48 tons (£5,733) in 1912.

The official statistics of the several states are silent as to how, where, and to what extent this concentrated ore is smelted. However, exports from the Commonwealth during 1912 included 3875 long tons of tin metal (£790,588); 3078 tons of tin ore (£392,082); and 158 tons of tin ore concentrates (£18,727). The *Metallgesellschaft* credits Australia with an output of 5050 long tons of tin metal, and a domestic consumption of about 1180 long tons of metal in 1912.

New South Wales.—The chief production of tin ore is obtained by dredges, of which thirty-nine, employing 750 men, were engaged in 1912. The output of the dredges in 1912 was 1621 tons, valued at £223,813, which was £15,718 in excess of the production of 1911. The most successful results were secured by the dredges in the Emmaville division, where 744 tons were obtained. In the Tingha division, the recovery amounted to 714 tons valued at £98,495. In the Wilson's Downfall division the output was 140 tons. Small productions were also obtained from Bendeneer and Glen Innes. Of the thirty-nine tin dredges in operation, four were of the bucket type and thirty-five of the suction type. The value of the plants is estimated at £170,140. The four bucket dredges treated 503,653 cu. yd. of material, recovering therefrom 171 tons of tin ore, or 0.76 lb. per cubic yard, valued at 10.68d. The thirty-five suction dredges treated 2,313,753 cu. yd. of material, recovering 1336 tons of ore or 1.29 lb. per cubic yard, valued at 19.21d.

Queensland.—The total output of concentrated tin ore in 1912 was 3230 tons valued at £364,503, as compared with 3091 tons worth £307,-

847 in 1911. No important discoveries of new deposits were made during 1912, but considerable activity was shown in the development of productive mines. In the Herberton district, the principal productive region, the Vulcan mine finished the year with enough ore available above the 900-ft. level to assure a number of years' further production. The Irvinebank Co. increased its holdings during the year. The Governor Norman mine has improved the grade of its ore by recent development and has added ten stamps to its Loudon mill. This mill and the Mt. Agnes mill were both operated at full capacity, partly on custom ore from the vicinity. At Koorboora, the Two Jacks and the Tennyson mines kept the local mill well supplied with ore. At Sunnymount, in the northern district, the Tommy Burns and the Prince Alfred developed promising ore-bodies. The cost of transport and treatment at the latter mine amounted to £2 10s. per ton. The mines and equipment formerly owned by the Stannary Hills Mining Co. passed into the hands of Darling & Son, of Adelaide, and many of its mines are now being worked by tributers.

Lode tin in the Herberton district would thus appear to be a fairly lucrative pursuit, and if tin remains at its present price, an increase in production may be looked for, not alone from rich deposits such as those at Silver Valley and elsewhere, but from the countless bodies of low-grade ore which persistent efforts to reduce the costs of milling and transport are gradually bringing within the sphere of profitable treatment.

Of the seventeen plants for concentrating tin ore in the Herberton and Chillagoe districts, four were entirely idle during the year; eight were partially idle; and a new mill, the Emuford, was active for only 5 months. The Irvinebank Company's smelter of 24 tons daily total capacity, comprising two reverberatory furnaces, was in continuous operation at about half capacity throughout the year.

The high price of stream-tin prevailing in 1912, £7 10s. per cwt., revived interest in alluvial workings. Extensive deposits of tin-bearing gravels have recently been noted at elevations well above the present river channels; in some cases these are covered with volcanic flows. It is intended to devote considerable attention to such deposits. The principal localities at which alluvial mining is conducted are the Kangaroo Hills; Cooktown; Stanthorpe, where five new concerns have been formed; Charters Towers; and Rocky Creek. Recent developments at Croydon were unsatisfactory.

Tasmania.—The production of concentrated tin ore in Tasmania during 1912 amounted to 3714 long tons, valued at £543,103 as compared with 3953 long tons worth £513,500 in 1911. The principal producers are the Mt. Bischoff, with an output of 1110 tons; the Briseis, with an

output of 539 tons; and the Pioneer, yielding 468 tons during 1912. In connection with the treatment of tailings from the Tasmanian tin dressing works, a process has been invented by which it is claimed that the total metallic tin contents of such material can be extracted at a cost of 7 to 8s. per ton. The process consists in mixing with the tailings 5 per cent. of salt, 5 per cent. of charcoal, and a small amount of bromine. The mixture is then heated to 1,600° F., from 3 to 5 minutes. The volatized tin fumes are then condensed in brick-flues, where the greater portion falls as a dry, white powder, stannous chloride, and the remainder as stannic chloride; the latter is soluble in water and the former in weak acid, from which the metallic tin can be precipitated by usual means.

In western Australia, two tin lodes were discovered early in 1912 in the Poonah-Coodardy district, 43 miles west of Cue. A test on 25 tons of ore run through the Great Fingall mill yielded 4 per cent. cassiterite.

*Austria.*—An increased amount of low grade (1.5%) tin ores were worked in Falkenau, Bohemia, where 900 tons were treated in 1911.

*Bolivia.*—This country has for several years occupied a position second only to that of the Federated Malay States in the production of tin ore. From 500 to 1000 tons of metallic tin are annually smelted in Bolivia, but the majority of the concentrated ore, *barrilla*, is exported, via Autofagasta, Chile, to England, France and Germany. It has been customary to compute the metallic contents of these concentrates at 60 per cent., but it is stated (*Min. Journ.*, March 15, 1913) that 57 per cent. is nearer correct. According to the official figures of *Revista de Aduanas*, the exports of *barrilla* during 1912 were 38,379 metric tons, valued at 59,870,776 Bol.—$23,289,732, on which duties to the amount of $1,076,471 were collected. Since 1908 the annual output has increased 28 per cent. in amount, but owing to the higher prices of recent years, the value of the output has increased by 94 per cent. in the same period.

EXPORTATION OF TIN ORE FROM BOLIVIA.
(In metric tons.)

| Year. | *Barrilla.* Tons | Tin Contents. (*a*) | Year. | *Barrilla.* Tons. | Tin Contents. (*a*) |
|---|---|---|---|---|---|
| 1901 | 21,573 | 12,943 | 1907 | 27,678 | 16,607 |
| 1902 | 17,340 | 10,404 | 1908 | 29,938 | 17,963 |
| 1903 | 21,785 | 13,071 | 1909 | 35,566 | 21,340 |
| 1904 | 20,369 | 12,221 | 1910 | 38,548 | 23,129 |
| 1905 | 27,690 | 16,614 | 1911 | 37,073 | 22,244 |
| 1906 | 29,370 | 17,624 | 1912 | 38,379 | 23,027 |

(*a*) Tin content of the barrilla (black tin concentrate), computing the latter at 60 per cent. metallic tin.

RECEIPTS OF BOLIVIAN TIN AT LIVERPOOL, HAVRE, AND HAMBURG. (a)
(In tons of 2240 lb.)

| Year. | Liverpool. | | | | Havre. Tons Fine. | Hamburg. Tons. Fine. |
|---|---|---|---|---|---|---|
| | Bars. | Ore. | | Total Tin. | | |
| | | Crude Weight. | Metallic Content. | | | |
| 902 | 1,685 | 10,961 | 6,576 | 8,261 | ..... | ..... |
| 903 | 1,614 | 10,401 | 6,240 | 7,854 | ..... | ..... |
| 904 | 1,573 | 13,824 | 8,294 | 9,867 | ..... | ..... |
| 905 | 1,386 | 17,504 | 10,504 | 11,888 | ..... | ..... |
| 906 | 1,569 | 20,489 | 12,293 | 13,862 | 691 | 1,827 |
| 907 | 1,143 | 18,532 | 11,119 | 12,262 | 924 | 2,390 |
| 908 | 1,174 | 21,502 | 12,901 | 14,075 | 863 | 2,056 |
| 909 | 834 | 22,859 | 13,716 | 14,550 | 1,216 | 2,275 |
| 910 | 1,003 | 24,524 | 14,724 | 15,727 | 808 | 1,690 |
| 911 | 464 | 29,676 | 17,805 | 18,269 | 1,155 | 3,170 |
| 912 | 552 | 20,694 | 12,416 | 12,968 | 545 | 7,655 |

(a) As reported by H. A. Watson & Co., Liverpool.

*Chile.*—Tin ores to the declared value of $20,700 were exported to the United States during 1912. A new discovery of lode tin ore is reported from Atacama Province.

*China.*—Exports of Chinese tin attained a record figure in 1912, trade having been particularly active during the first half of the year. According to official figures of the Maritime Customs Office, exports of tin in 1912 amounted to 145,227 piculs, or 8785 metric tons, compared with 6056 metric tons in 1911. The principal source of the ore is near Mengtze, in Yunan province; a little comes from Kwang-si province. Most of the ore is smelted, and all of the crude tin is refined, at Hong Kong, where the entire export trade is centralized. The continent of Europe takes approximately half of the total exports; England takes one-quarter, and one-quarter comes to the United States.

Yunnan tin is classed in three grades, No. 1 being 98.5 to 99 per cent. pure tin; No. 2 being 97.5 to 98 per cent., and No. 3 being 95 to 96 per cent. Current prices at Hong Kong, July 1, 1912, per pikul of 133 1/3 lb., were $117.50 in Hong Kong dollars, for No. 1; $115.50 for No. 2 and $111 for No. 3. At current exchange these prices were equivalent to 43.45 cents, 42.7 cents and 41 cents per pound, respectively.

It is reported from Yunnan that a railway connecting the tin mines at Kochiu, with the main French line from Haiphong to Yunnanfu, at Mengtze, is to be built by a French firm (*Min. Journ.*, Nov. 16, 1912). Further, it is said that the great smelting plant at Kochiu is about to be operated for the first time. The Germans built it at the cost of $1,000,000, but it was never assured of a definite ore supply. The building of the railroad will overcome this difficulty

According to accounts in the native press a placer tin deposit has

been discovered near Funglin village, Kityang district, which is within the Swatow consular district. It is estimated that 100 lb. of pure tin will be yielded by this placer daily.

A company with $375,000 (gold) capital is to be formed to acquire an area of 1 square mile in the new (British) territory, the Kowloon extension, for the purpose of working the tin deposits which have been known for some time to exist there, and have recently been carefully prospected. The mining district is in the valley of Unlong, close to Deep Bay, and junks can approach to within 2 miles of the property. It is thought that by June, 1913, the extension of the Kowloon-Canton railway will be completed, and this will approach much closer to the concession. In any case the transportation to Hong Kong will not cost more than $8 gold per ton.

*Dutch East Indies.*—The U. S. Consul at Batavia reports that the production of Banca tin during 1912 was 24,995,440 lb. (11,336 metric tons), an increase of 523,872 lb. over 1911. The tin mines of the island of Banca are largely owned by the Dutch Government and are leased to miners, while tin mining in the island of Billiton is carried on in a similar way through a large concessionary company. Sales of Billiton tin, by public auction at Batavia during 1912, amounted to 4,936,800 lb. (2239 metric tons); the average price was 43.25 cents per pound. The *Metallgesellschaft* reports sales of Banca tin in Holland at 16,111 tons during 1912.

*Federated Malay States.*—Exports of tin and tin in ore (the metal contents of the latter being estimated at 70 per cent. for purposes of taxation) amounted to 813,472 piculs (49,215 metric tons) in 1912, an increase of 4345 metric tons, or nearly 10 per cent. over 1911. The increase was undoubtedly due to the high prevailing price for tin, $103.30 (U. S.) per picul, prevailing during the year.

PRODUCTION OF TIN IN THE FEDERATED MALAY STATES. (a).
(In Pickuls of 133⅓ lb.)

| | 1904. | 1905. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|---|---|
| Perak..... | 443,507 | 446,781 | 435,909 | 431,386 | 467,784 | 461,665 | 421,335 | 437,339 | ..... |
| Selangor..... | 300,413 | 289,867 | 268,624 | 273,900 | 282,540 | 266,007 | 240,192 | 231,175 | ..... |
| Negri Sembilan | 84,849 | 85,133 | 77,766 | 75,155 | 64,221 | 48,072 | 34,697 | 29,230 | ..... |
| Pahang..... | 27,469 | 34,879 | 34,488 | 33,195 | 39,520 | 43,144 | 40,674 | 43,954 | ..... |
| | | | | | | | | | ..... |
| Total..... | 856,238 | 856,660 | 816,787 | 813,636 | 854,065 | 818,888 | 736,898 | 741,698 | 813,472 |
| Metric tons ... | 51,790 | 51,793 | 49,859 | 48,411 | 51,654 | 49,529 | 44,579 | 44,870 | 49,215 |

(a) Exports of tin ore, the latter being calculated to its assumed metal contents, upon which duty is paid to the F. M. S. government.

Tin mining in the Malay States was the subject of an excellent report by D. C. Alexander, Jr., special agent for the U. S. Department of Com-

merce and Labor, published in 1912 as No. 59 of the Special Agents Series, from which the following data are extracted: While tin is found in place in quartz veins, the richer and more easily worked alluvial deposits receive the most attention. Nevertheless a 20-stamp mill for a quartz deposit is in process of erection by the Menglembu Lode Syndicate near Ipoh and another mill is being installed near Bentong. A reduction of the export duty on tin and ore varying up to 50 per cent. is granted to properties of too low a grade to show a profit under the full duty.

The alluvial deposits are found in valleys adjacent to tin-bearing granite. An excellent example is the Kinta Valley of Perak, 30 miles long with an average width of 5 or 6 miles between hills 300 to 400 ft. high. The tin-bearing ground is called "karang." The open-cast method of handling the ground is the most important; the underground method using shafts is going out of use; and the "lampan," or ground-sluicing method, is of much less importance than the open-cast. Underground mining and ground sluicing are usually conducted on a small scale by Chinese. Chinese also operate many of the open-cast mines, and it is estimated that 78 per cent. of the annual output is produced from mines operated and owned by them.

After removing the overburden, the material from the open-cast mines is hoisted on inclines and washed in circular tanks by mechanical agitation. The slime overflow from these tanks is concentrated by flowing over riffles, which catch the cassiterite. A small proportion of the ore is found in quartz pebbles, which remain in the washing tank and must be crushed, either by stamps or by more primitive methods, for further treatment. It is said, however, that fully 90 per cent. of the ore in the "karang" is recovered on the riffles. The clean ore is dried in a perforated cylinder, placed around a cone-shaped stove. Wolfram, if present, is removed by ordinary horseshoe magnets. Power of various kinds is employed, even man-power in tread mills. Steam power is being gradually abandoned for gas producers and gas engines. Coal is obtained from Wales, China, Bengal or Borneo, this being the order of its excellence.

One of the best known mines is the Tambun, owned and operated by Towkay Leong Fee. This has produced as much as 3600 long tons of ore in a year. A contract system is employed with excellent results. The smelting plant for this mine is of a simple, primitive Chinese type, in which the blast is furnished by a single-acting piston in a wooden box 5 or 6 ft. long. Satisfactory results are obtained, both in quality and in cost. A similar mine is the Lahat which produced 548 long tons of ore in 1910, averaging 74 per cent. tin. The most famous mine is the Tronoh, which in 1911 produced 2083 long tons of ore in 4 months. Nearly 6000 men are employed here.

For the hydraulic mines, natural water power is sometimes available and sometimes a power plant must be installed. Of the mines operating under a natural head of water the Tekka is the largest and best known. The system includes the use of monitors and hydraulic elevators with concentration on riffles, supplemented by hand concentration with an implement similar to a *batea*. Eight monitors are in operation.

The Pengkalen is the largest and most modern of the hydraulic mines using generated power. The equipment includes three 40-h.p. water-tube boilers, engines and generators, electrically operated Worthington centrifugal pumps for the monitors, gravel pumps instead of hydraulic elevators, and drainage pumps. The cost of raising and treating the earth in this mine is about $0.315 per cubic yard. In the Tekka mine it is $0.07 and in the open-cast mine it varies from $0.34 to $0.52 per cubic yad. In the hydraulic mines the overburden is handled along with the karang.

Of the tin exports about 22¼ per cent. is in the form of block tin from local Chinese smelters. Of the rest, exported as tin ore, about 80 per cent. is smelted by the Straits Trading Co. at Singapore, and the Eastern Smelting Co. at Penang, which smelters also receive a small amount of ore from Australia and South Africa There is an export duty on ore and metal, so adjusted as to penalize shipments of ore elsewhere than to the Straits Settlements or to England. The smelters buy the ore outright and pay for the contained tin less an amount varying from $18 to slightly over $20 per short ton. Out of this deduction, the smelter pays freight charges, averaging $8.55 (U. S.) per short ton.

IMPORTS OF TIN AND TIN ORE INTO GERMANY.
(In metric tons.)

| Country. | Tin Ore. | | | | Country. | Tin Metal. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1909. | 1910. | 1911. | 1912. | | 1909. | 1910. | 1911. | 1912. |
| Bolivia | 13,099 | 15,925 | 15,227 | 13,296 | Dutch Indies | 7,596 | 8,135 | 8,210 | 7,254 |
| Chile | 978 | 914 | 1,874 | 2,133 | Australia | 1,826 | 1,129 | 1,161 | 1,519 |
| Spain | 672 | 227 | ..... | ..... | Straits Settlement. | 671 | 471 | 249 | 494 |
| Austria-Hungary | 190 | 48 | ..... | ..... | Great Britain | 1,390 | 1,302 | 1,524 | 1,644 |
| Great Britain | 324 | 34 | 320 | 102 | British Indies | 1,058 | 1,105 | 1,266 | 1,387 |
| Other countries | 160 | 195 | 550 | 1,026 | Other countries | 996 | 2,155 | 2,140 | 3,252 |
| Total | 15,423 | 17,343 | 17,971 | 16,557 | Total | 13,537 | 14,297 | 14,500 | 15,550 |
| Value (1000 M.) | 20,050 | 26,709 | 35,921 | 33,114 | Value (1000 M.) | 36,414 | 43,773 | 55,282 | 59,244 |

*Russia.*—A group of capitalists has been making explorations in the basins of the Sosnowice and Dombrowa, in Poland, to discover tin ore. Tin ore is at present known near Kogroufka, says *Echo des Mines*, Mar. 25, 1912, where the deposits attain a thickness of about 1.25 m. The commercial exploitation of these ores will be undertaken shortly.

A group of German capitalists of Berlin and Hamburg, with the coöp-

eration of the St. Petersburg International Bank, has formed a company for the exploitation of tin mines in the Neichinsk district of Transbaikalia, 3.5 miles from Olovyanka, on the Transbaikal Ry., says the *Mining Journal*, May 25, 1912. Tin ore has been known to exist here since 1811. Recently investigations were made, and it was seen that the veins are of considerable extent and of great number. In the neighborhood of the Pervonachalny placer there are sandy strata with stanniferous ore 2/3 to 2 1/2 ft. thick. In this district there are also the known Kulundinsky, Sharanaisky, and Zavitinsky tin placers. The Transbaikal Tin Smelting Works will be the pioneer of the tin industry in Russia.

*United Kingdom.*—The production of dressed tin ore (averaging 65 per cent. metal) from deep mines in 1912 was 6817 long tons. Adding an estimated output of 1200 tons (averaging 45 per cent. metal) recovered from quarries, stream workings, old dumps, etc., for which statistics are not yet available, gives a total of 8017 long tons, containing 4981 tons of metallic tin in 1912, compared with 7746 tons of ore containing 4872 tons of tin for 1911.

Imports of tin ore, mainly from Bolivia and South Africa, are stated in the table. The metallic yield of these imported ores is not officially stated, but is estimated by the *Metallgesellschaft* at 13,386 long tons in 1912.

IMPORTS OF TIN ORE INTO GREAT BRITAIN.

| | 1910. | | 1911. | | 1912. | |
|---|---|---|---|---|---|---|
| | Long Tons. | £ | Long Tons. | £ | Long Tons. | £ |
| South America..... | 19,982 | 1,362,134 | 21,439 | 1,738,059 | 21,085 | 1,869,847 |
| British South Africa.. | 3,339 | 290,427 | 3,407 | 342,031 | 826 | 99,235 |
| Other countries..... | 2,751 | 168,221 | 3,991 | 226,106 | 6,741 | 431,804 |
| Total..... | 26,072 | 1,820,782 | 28,837 | 2,306,196 | 28,652 | 2,400,886 |

IMPORTS OF METALLIC TIN INTO GREAT BRITAIN.

| | 1910. | | 1911. | | 1912. | |
|---|---|---|---|---|---|---|
| | Long Tons. | £ | Long Tons. | £ | Long Tons. | £ |
| Straits Settlements, Malay States and Labuan. | 40,604 | 6,294,052 | 39,691 | 7,566,633 | 36,069 | 7,501,484 |
| Australia..... | 3,872 | 601,132 | 3,571 | 679,960 | 3,244 | 677,066 |
| Other countries..... | 1,809 | 264,598 | 2,644 | 492,879 | 3,844 | 791,594 |
| Total..... | 46,285 | 7,159,782 | 45,906 | 8,739,472 | 43,157 | 8,970,144 |

TIN SUPPLY OF GREAT BRITAIN.
(In long tons.)

| | 1910. | 1911. | 1912. |
|---|---|---|---|
| From domestic ores (*a*) | 4,797 | 4,872 | (*e*)4,981 |
| From imported ores(*b*) | 12,850 | 13,632 | 13,386 |
| Imported metal | 46,285 | 45,906 | 43,157 |
| Total supplies | 63,932 | 64,410 | 61,524 |
| Exports (*c*) | 31,539 | 34,025 | 32,733 |
| Consumption(*d*) | 32,393 | 30,385 | 28,791 |

(*a*) Amount of tin "obtainable" by smelting; the exact recovery is not stated. (*b*) Estimated by the *Metallgesellschaft*. (*c*) Of foreign origin only. (*d*) Disregarding fluctuations in stocks. (*e*) Partly estimated.

## The Tin Markets

*London.*—January saw an active market, but with fluctuations many and wide. Straits tin was scarce, the supply commanding up to £205 per ton for prompt delivery; standard tin for similar delivery being quoted £192, and for three months' delivery £184 10s. The lowest prices for standard were recorded on Jan. 12, £184 for cash and £182 for three months. At the periodical Banka auction 2614 tons were sold for £194 15s. Closing prices for standard were £194 15s. cash, and £192 2s. 6d. three months.

About the middle of February, £198 10s. was paid for several spot parcels. Trade demand was large and constant. Closing prices were £193 for cash standard and £189 10s. for three months.

The strike of British coal miners in March greatly restricted consumption of the metal in the United Kingdom. Speculative enterprise was attracted to other markets, and price of standard drifted down to £189 10s. cash and £2 to £5 5s. less for extended delivery. At the Banka auction in Amsterdam 2640 tons were sold at the relatively high equivalent of £201 5s. Toward the close, standard was quoted £195 prompt; £191 three months.

In April prices advanced persistently, only checked occasionally by bear raids until, on Apr. 29, cash standard touched £215, and three months £212; closing prices being £210 and £208.

Toward the end of May trans-shipments were impeded by a strike of dock laborers in London, supplies had to be drawn from public warehouses, and dealers were in difficulties as to fulfillment of their contracts. The result was a sensational advance to £215 10s. for early delivery, the three months' price being, however, no better than £203 10s. Thereafter followed a rapid decline, partly induced by the sale of Banka in Amsterdam, whereat the average price was equivalent to £199 10s. Heavy shipments from the Straits contributed to the depression, and closing

prices were the lowest of the month, £200 for prompt delivery and £195 for three months.

In June the cash price varied between £200 and £208. Closing prices were £209 cash and £203 15s. for three months.

In July values drifted down to £195 10s. cash. and £194 for three months. At the Amsterdam auction, 2640 tons Banka were sold to keen bidders at the average equivalent of £210 7s. 6d. Closing prices in London were £205 5s. cash, and £203 for three months.

In August prices declined to £202 5s. cash, and £199 10s., respectively. Closing prices were £218 5s. cash, and £217 5s. for three months.

In September there was a relapse of about £2 per ton. Demand then revived and the upward rush was intensified by a revival of American demand long overdue. When the cash price touched £227 15s., an organized bear attack achieved a temporary relapse of £6 per ton, but failed to dislodge any important quantities. The upward movement recommenced and was unchecked until—on Sept. 26—£233 was paid for prompt delivery, and £231 10s. for three months. In Amsterdam, 2640 tons of Banka were sold at the relatively low equivalent of £224 12s. 6d. Closing prices were £230 15s. cash, and £229 5s. for three months.

In October an initial relapse of £4 per ton was soon recovered under the persistent trade demand, particularly from America, and the market was comparatively uneventful down to Oct. 14, when—in sympathy with a general panic on the Stock Exchange—the three months' price fell to £220. Purchasing induced a recovery to £232 for cash, and £230 15s. for three months. The market closed at £229 5s. for cash, and the same price for three months.

In November, favorable statistics induced an opening advance to £230 5s. for prompt delivery, and £229 15s. for three months, which proved to be the highest of the month. At the higher prices Eastern holders showed more willingness to sell, and American consumers less readiness to buy; and business was impeded by the continued hostilities in Southern Europe. The Dutch sale of Banka disposed of 2685 tons at the average equivalent of £226 15s. Closing prices were £225 15s. for cash and £225 12s. 6d. for three months.

December opened with a lower tendency, but a good demand developed and toward the middle of the month prices advanced. During all this month the backwardation disappeared and the prices for futures were equal to or slightly higher than spot. This continued till the close, when a backwardation again developed. The close was at the highest of the month, £229 10s. for spot and £229 for three months.

*New York.*—The excellent position in which tin finds itself, statistically speaking, became more pronounced during 1912. The production

which, during the past few years, has but slightly increased, has hardly kept pace with the growing consumption of the metal in all quarters of the world. The increase in consumption has mainly taken place in the United States, where the tin-plate industry, especially, was very prosperous during 1912. These favorable conditions made it easy for the European syndicate, which controls the tin market of the world, to manipulate it in the upward direction. The new contract for Standard tin was introduced on the London Metal Exchange at the beginning of February, 1912. Under its rules, other brands of tin than the Straits, Malacca or Australian brands, which previously formed the only good delivery against the Metal Exchange contracts, can be delivered, thus avoiding the violent fluctuations of former days brought about by a squeeze of the shorts.

The year started in with a very weak market, due to the financial embarrassment of one of the London metal houses interested in tin. Prices quoted were about 42 cents for January tin, while spot tin was exceedingly scarce and commanded a premium of up to 1 1/2 cents per lb. At this level a good deal of tin was purchased by American consumers, with the result that the London market became firmer and stayed around 43 cents per lb. until the beginning of March. The dock strike which broke out at the beginning of March tended to unsettle the tin market, owing to the fear of smaller deliveries, which would affect statistics unfavorably. This influenced domestic buyers, who previously had taken good sized quantities, but who then became reluctant in continuing their purchases. The market declined to about 42 cents until the latter part of March. Then it became strong again on heavy American buying, and the price moved back to 43 cents, where it remained until about the middle of April. About this time it became apparent that consumption of tin was so heavy as to run ahead of production. In consequence, visible supplies decreased continuously. The market became exceedingly strong and advanced very rapidly to over 46 cents per pound, on which level it remained until about the middle of May. Heavy shipments from the East which were then cabled affected the market unfavorably and it declined to about 45 cents. About the middle of June it was found that the large shipments from the Straits could not be handled readily on account of the London dock strike, and that stocks in warehouse had dwindled to almost nothing. Prompt material became exceedingly scarce, and a premium of as much as £10 was paid over future material. The New York market was similarly affected, and spot tin was selling at about 3 cents over shipment tin, which latter was quoted at about 45 1/2 cents. The larger arrivals of tin, shipped direct to this port from the East Indies, alleviated the scarcity, and prompt material became more plentiful.

In July the market became weak in sympathy with the decline in London, and remained at 43 1/2 @ 43 3/4 cents per pound until the end of that month. At that time it became known that the Banka tin available during 1913 would be about 1800 tons less than that sold during 1912. This fact, coupled with the very much better demand from the United States, had a hardening effect on the London market. Prices advanced to about 45 1/2 cents. During August the market fluctuated slightly, but in the main retained its strong tone. When the excellent statistics for August became known at the beginning of September, the market developed a great deal of strength, and advanced rapidly to about 50 cents about the middle of September. A reaction of about £5 in the London market affected the domestic market to a like extent, and prices declined to 48 3/4 cents per pound for September delivery. This decline was, however, rapidly recovered and the end of the month saw prices again at over 50 cents per pound. The American buyers were rather chary in contracting ahead for their requirements on this basis, and only covered their absolute needs.

AVERAGE MONTHLY PRICE OF TIN IN LONDON. (*a*)
(In pounds sterling per ton of 2240 lb.)

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. |
|---|---|---|---|---|---|---|
| | £ s d | £ s d | £ s d | £ s d | £ s d | £ s d |
| 1900..... | 118 .9.11 | 137.18 .4 | 142 .0 .0 | 137.15 .0 | 135 .1 .8 | 139 .9 .3 |
| 1901..... | 120 .9.10 | 122 .6.11 | 116.15 .6 | 116 .3 .0 | 123.13 .0 | 129.16.11 |
| 1902..... | 105. 6 .5 | 114 .4 .9 | 115.10 .6 | 125.14 .2 | 134.13.10 | 129.12.10 |
| 1903..... | 127.12 .6 | 133 .8 .1 | 137 .0 .6 | 136.19 .2 | 133.12 .0 | 127.11 .0 |
| 1904..... | 130.10 .4 | 125.13 .6 | 126 .9 .8 | 127 .5 .1 | 125 .7 .2 | 119.11 .1 |
| 1905..... | 131 .5.11 | 131 .3 .6 | 134.17 .2 | 140.11 .8 | 136.11 .8 | 138 .3 .6 |
| 1906..... | 164.11.10 | 166 .0.10 | 166 .1 .2 | 176.14 .5 | 192 .6 .4 | 178 .0 .7 |
| 1907..... | 190 .4 .0 | 191.18 .9 | 188.17 .6 | 187 .1 .2 | 191 .1.10 | 187.10.11 |
| 1908..... | 128 .9 .0 | 128.14 .1 | 137.19 .8 | 143.12.10 | 135.11 .6 | 127.12 .2 |
| 1909..... | 127 .7 .3 | 127.15 .3 | 130 .6 .7 | 133 .8 .3 | 131.16.10 | 133 .4 .0 |
| 1910..... | 148 .3 .6 | 149.13 .0 | 147 .4.11 | 149.19 .3 | 150 .1 .8 | 148.13 .1 |
| 1911..... | 187.17.11 | 189.12.10 | 182.12 .4 | 193 .0.10 | 197.15 .4 | 207 .7 .9 |
| 1912..... | 191.14 .0 | 195 .4.10 | 192.15 .0 | 200 .8 .3 | 209 .6 .1 | 205.18 .9 |

| Year. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|
| | £ s d | £ s d | £ s d | £ s d | £ s d | £ s d | £ s d |
| 1900..... | 142.16.10 | 140.19 .1 | 132.13 .9 | 130.14 .3 | 127 .3 .8 | 119.14 .9 | 133.11 .6 |
| 1901..... | 127.19 .9 | 116 .1 .7 | 114.10 .6 | 113 .1 .5 | 114 .0 .7 | 108.17.10 | 118.12 .8 |
| 1902..... | 127 .3 .2 | 126.10 .0 | 121.10 .7 | 117.11 .3 | 115 .2 .3 | 115.13 .5 | 120.14 .5 |
| 1903..... | 125 .1 .7 | 127.16.10 | 120 .9 .6 | 115.17 .1 | 116.13 .9 | 125.15 .0 | 127 .6 .5 |
| 1904..... | 119.18 .6 | 122 .5 .9 | 126 .7 .7 | 130.11 .6 | 133 .0 .5 | 133.15 .6 | 126.14 .8 |
| 1905..... | 144 .6 .8 | 150 .5 .6 | 146.11 .9 | 148 .3 .6 | 152 .5 .3 | 162.14 .3 | 143 .1 .8 |
| 1906..... | 170.12 .5 | 180.19.11 | 184.15 .3 | 195.15.11 | 195.15.10 | 195.19 .9 | 180.12.11 |
| 1907..... | 188 .0 .2 | 170 .5 .9 | 166 .6 .6 | 146 .7 .7 | 138 .8 .8 | 125.10 .4 | 172.12 .9 |
| 1908..... | 131 .6.10 | 134.16 .2 | 131 .6 .8 | 133 .8 .8 | 137 .8 .3 | 132 .4 .7 | 133 .2 .6 |
| 1909..... | 131.19 .1 | 135.18 .3 | 137.14 .6 | 138.13 .2 | 140 .0 .3 | 149 .2 .3 | 134.15 .6 |
| 1910..... | 149 .2 .1 | 155 .8 .2 | 160 .8 .7 | 164 .4 .9 | 166.18 .0 | 173.17 .3 | 155 .6 .2 |
| 1911..... | 193 .2 .0 | 190 .9 .7 | 180.16.11 | 187 .2 .9 | 194.19 .4 | 203 .7 .2 | 192 .7 .$\frac{1}{2}$ |
| 1912..... | 202 .8 .3 | 208 .3 .0 | 223.19 .6 | 228 .9 .1 | 227.16.10 | 226.17 .8 | 209 .8 .5 |

(*a*) As reported by Metallgesellschaft, Frankfurt-am-Main.

AVERAGE MONTHLY PRICES OF TIN PER POUND IN NEW YORK. (a)

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. |
| 1898 | 13.87 | 14.08 | 14.38 | 14.60 | 14.52 | 15.22 | 15.60 | 16.23 | 16.03 | 17.42 | 18.20 | 18.30 | 15.7[illegible] |
| 1899 | 22.48 | 24.20 | 23.82 | 24.98 | 25.76 | 25.85 | 29.63 | 31.53 | 32.74 | 31.99 | 28.51 | 25.88 | 25.1[illegible] |
| 1900 | 27.07 | 30.58 | 32.90 | 30.90 | 29.37 | 30.50 | 33.10 | 31.28 | 29.42 | 28.54 | 28.25 | 26.94 | 29.9[illegible] |
| 1901 | 26.51 | 26.68 | 26.03 | 25.93 | 27.12 | 28.60 | 27.85 | 26.78 | 25.31 | 26.62 | 26.67 | 24.36 | 26.7[illegible] |
| 1902 | 23.54 | 24.07 | 26.32 | 27.77 | 29.85 | 29.36 | 28.38 | 28.23 | 26.60 | 26.07 | 25.68 | 25.68 | 26.7[illegible] |
| 1903 | 28.23 | 29.43 | 30.15 | 29.81 | 29.51 | 28.34 | 27.68 | 28.29 | 26.77 | 25.92 | 25.42 | 27.41 | 28.0[illegible] |
| 1904 | 28.85 | 28.09 | 28.32 | 28.13 | 27.72 | 26.32 | 26.57 | 27.01 | 27.78 | 28.60 | 29.18 | 29.292 | 27.9[illegible] |
| 1905 | 29.325 | 29.262 | 29.523 | 30.525 | 30.049 | 30.329 | 31.760 | 32.866 | 32.095 | 32.481 | 33.443 | 35.835 | 31.3[illegible] |
| 1906 | 36.390 | 36.403 | 36.662 | 38.900 | 43.313 | 39.260 | 37.275 | 40.606 | 40.516 | 42.852 | 42.906 | 42.750 | 39.8[illegible] |
| 1907 | 41.548 | 42.102 | 41.313 | 40.938 | 43.149 | 42.120 | 41.091 | 37.667 | 36.689 | 32.620 | 30.833 | 27.925 | 38.1[illegible] |
| 1908 | 27.380 | 28.978 | 30.577 | 31.702 | 30.015 | 28.024 | 29.207 | 29.942 | 28.815 | 29.444 | 30.348 | 29.144 | 29.4[illegible] |
| 1909 | 28.060 | 28.290 | 28.727 | 29.445 | 29.225 | 29.322 | 29.125 | 29.966 | 30.293 | 30.475 | 30.859 | 32.913 | 29.7[illegible] |
| 1910 | 32.700 | 32.920 | 32.403 | 32.976 | 33.125 | 32.769 | 32.695 | 33.972 | 34.982 | 36.190 | 36.547 | 38.199 | 34.1[illegible] |
| 1911 | 41.225 | 41.614 | 40.157 | 42.185 | 43.115 | 44.606 | 42.400 | 43.319 | 39.755 | 41.185 | 43.125 | 44.655 | 42.2[illegible] |
| 1912 | 42.529 | 42.962 | 42.577 | 43.923 | 46.053 | 45.815 | 44.519 | 45.857 | 49.135 | 50.077 | 49.891 | 49.815 | 46.0[illegible] |

About the middle of October, when the troubles began among the Balkan States and Turkey, the tin market in London was adversely affected for a few days, scoring a maximum decline of about £7. However, it not only quickly recovered from this decline, but made further advances, so that quotations were established in this market at about 50 1/4 cents per pound about the middle of October. It remained on the basis of 50 cents per pound, with slight variations, until the end of November. The war in Southeastern Europe is said to have interfered greatly with a large part of the European consumption of tin, and while the American business continues to be satisfactory, orders from European consumers have, for the above reason, fallen off considerably. The market was but slightly affected by these considerations, and stood at about 49 1/2 cents per pound at the beginning of December. American consumption continued at a high rate, and purchases were therefore made on a liberal scale. This sustained the market, giving it a firm understone, with prices ruling at between 50 cents and 50 3/8 cents per pound, in New York, up to the end of the year.

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# TITANIUM

The principal sources of titanium as now us
poses are ilmenite and titaniferous ores, which car
ing amounts from 5 to 40 per cent., and rutile,
sometimes carry as high as 98 per cent. $TiO_2$.

Up to the present time most of the ilmenite u
been mined in the Province of Quebec. The rut
extent from Roseland County, Virginia. These
fine concentrates containing about 75 per ce
statistics as to the iron ore used, are unavailab
rutile concentrates is stated,[1] as 566 short ton
$44,480, and 275 tons in 1912.

The only producer in Virginia in 1912 wa
Company. Two kinds of ore are worked by th
composed of feldspar, quartz, and rutile, and th
hornblende and ilmenite. The concentrates fr
rock, contain more than 94 per cent. $TiO_2$. The
concentrate by electro-magnetic separation, co
cent. $TiO_2$ and about 40 per cent. of iron oxid
concentrates produced in 1912, was about 80 pe
these rocks appears to be unlimited. A second ar
been discovered in Goochland and Hanover Co
pecting for rutile has also been reported at Mag
production is noted in 1912.

The treatment of the rutile rock is performed
separators. According to examination of thin
ore which have been treated on magnetic machin
less of the titanium,[2] the molecules are intima
to a titanomagnetite mineral. Grains of magnet
quite pure, were found to contain 6 to 7 per cent.

There are large deposits of titaniferous iro
magnetite and ilmenite, in Essex County, Nev
which carry about 46 per cent. iron and 12 per ce
trated, an iron concentrate carrying approximate
7 per cent. titanium is obtained, while concentrat

[1] *U. S. Geol. Surv.*
[2] Joseph T. Singewald, Jr., *Econ. Geol.*, April 13, 1913.

tailings would produce an almost pure ilmenite carrying about 30 per cent. titanium.

These iron concentrates are very low in phosphorus and should prove very valuable in Bessemer practice, if it can be demonstrated that the amount of titanium which they carry will not prevent their being successfully used in furnace mixtures.

It is understood that the company owning these Adirondack deposits is now engaged in mining and concentrating a sufficient quantity of its ore for an extensive furnace test on this grade of concentrates.

In foreign countries a small production of rutile is reported in Norway. In 1910 deposits at Kragero produced about 50 tons; in 1912 an export of 100 tons containing 95 per cent. $TiO_2$ was reported. The largest mines are near the south coast and are owned by Herman Jensen, Risor, and by the Christiania Minekompani, Kristiania.

The uses of titanium are chiefly in the form of ferro-carbon-titanium for treating steel and also cast iron and other metals. The production in the United States of ferro-titanium, can be judged by the fact that in 1911, 410,600 gross tons of steel were treated, and that 1643 long tons of ferro-titanium alloy was shipped by one American producer, to 79 manufacturers. Half of the steel was rail steel. In 1912 approximately 600,000 tons of steel were treated, and about one-quarter of this tonnage was rail steel.

The production of ferro-carbon-titanium in 1912 was reported to the American Iron & Steel Association as amounting to 3763 net tons.

The function of ferro-carbon-titanium in steel is that of a cleanser. It also serves to reduce segregation of phosphorus, sulphur and carbon to a very considerable degree and statistics show that it is being used more extensively each succeeding year. The imports of ferro-titanium in 1911 amounted to 51.17 tons; in 1912 the imports for consumption were 14 tons valued at $306, and 16.21 tons valued at $7335. The import duty on ferro-titanium is 25 or 20 per cent., depending upon the value per ton being less or more than $200.

Paul Girod states[1] that his works have decided to manufacture and to use silicon titanium, after a series of experiments in foundry practice. Silicon titanium alloy is practically free from carbon and of sufficient density to be added in the electric furnace before tapping and without remaining suspended in the slag. The alloy forms a very fluid slag separating readily. Silicon in the steel has been found low in experiments with electric steel furnaces, and usually with the exception of some special steels, the addition of silicon is necessary. The electric steel

[1] *Met. and Chem. Eng.*, Vol. XI, p. 9.

furnace practice is now sufficiently developed to do away with fear of any influence of an acid furnace cover on the silicon contents of the bath.

In the treatment of steel Mr. Auguste J. Rossi, has found that a better product is obtained by keeping the manganese contents between 0.18 and not exceeding 0.6 per cent. and raising the carbon. By adding ferro-titanium so that less than 1 per cent. remains in the product, the resulting rail steel is stated to have exceptional qualities. (United States patent 1028389, June 4, 1912.)

Titanium alloys are being used in electric steel practice for castings. The number of lost heats is very much diminished. It is claimed that ordinarily the de-oxidation is due to the formation of calcium carbide in the slag, and the formation of this in the electric furnace is not always controllable. As the technic in these processes has to be watched very carefully, it is questioned whether the use of silicon combined with ferro-titanium, is preferable to adding ferro-titanium and ferro-silicon separately.[1]

The influence of titanium on cast iron is one of the debated points of metallurgy. Rossi, Moldenke, West, and Goldschmidt have obtained favorable results, other investigators unfavorable.[2] The metal must not be cast too hot or too cold; the titanium must be got into the metal, not into the slag; and the melt must be given full time to absorb the titanium. Under these conditions it appears to reduce the amount of entrained slag, and probably through this, it seems to reduce segregation. It is not an alloying element, but works through its affinity for nitrogen, in which it stands first of all the elements, and for oxygen, in which it appears to stand between Si and Al (Keyser gives the heat of formation of $TiO_2$ at 97,772 cal.). In steel, 0.9 lb. per ton of steel is effective. While Stoughton believes either ferro-titanium or titanium-thermit to be advantageous, he believes the latter to be the less effective.

The uses of titanium to purify metals or alloys, such as zinc, lead, aluminum or jeweller's alloys, is the subject of recent patents granted to A. J. Rossi (covered respectively by U. S. pat. Nos. 1020514; 1020512; 1019531; 1022600).

Among the recent patents are a number given to A. J. Rossi for the production of titanium alloys. Probably the most interesting is the production of silico-titanium (U. S. pat. No. 1019526). Pure silica (white sand) and rutile are mixed with carbon in such proportions as to give the following reactions:

$$SiO_2+2C=2CO+Si$$
$$TiO_2+2C=2CO+Ti;$$

[1] N. Petinot, *Met. and Chem. Eng.*, Nov., 1912.
[2] Bradley Stoughton, *Eighth International Congress of Applied Chemistry.*

and heated in an electric furnace. By adding a metal or its oxide, and carbon to reduce it, a ternary alloy may be produced, of which the most promising would appear to be ferro-silico-titanium.

Pure *titanium* is made according to experiments in the Rensselaer Polytechnic Institute, Troy, N. Y., by Matthew A. Hunter. Titanium chloride, $TiCl_4$, was heated with pure sodium in a metallic bomb of about 1000 c.c., capacity. Pure titanium is hard and brittle and resembles polished steel in appearance, but does not break with the crystalline structure which is characteristic of the latter metal. All attempts made to draw it into wire have so far failed. The melting-point of titanium is approximately 1800° C., while the specific gravity is about 4.5 and the specific heat 0.1462.

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# TUNGSTEN

The decline in the tungsten ore industry which occurred during 1911 continued in 1912. The figures reported by producers in the United States, on a uniform basis of 60 per cent. tungsten oxide, account for an output of practically the same as in 1911. Owing to the irregular production and the irregular demand, actual prices cannot be estimated. The following table gives the production of tungsten concentrated in the United States in recent years:

PRODUCTION OF TUNGSTEN CONCENTRATE IN THE UNITED STATES. (a)
(In tons of 2000 lb.)

| Year. | Production. | Value. | Average per Ton. | Year. | Production. | Value. | Average per Ton. |
|---|---|---|---|---|---|---|---|
| 1903..... | 292 | 43,639 | $149 | 1908.... | 671 | 229,955 | 343 |
| 1904..... | 740 | 184,000 | 249 | 1909.... | 1619 | 614,370 | 379 |
| 1905..... | 803 | 268,676 | 334 | 1910.... | 2020 | 844,526 | 418 |
| 1906..... | 928 | 348,867 | 376 | 1911.... | 1293 | 500,247 | 387 |
| 1907..... | 1640 | [890,048 | 543 | 1912.... | 1290 | 580,500 | 450 |

(a) Statistics reported by the U. S. Geological Survey, except for 1910 and 1911.

The price per pound paid for tungstic acid, $WO_3$, rises as the tungsten content of the ore increases.[1] The following schedule was adopted, Dec. 1, 1912:

PRICES OF TUNGSTEN ORE, DEC. 1, 1912.

| Tungstic Acid in Ore, Per cent. | Price per Pound of Tungstic Acid, Cents. | Tungstic Acid in Ore, Per cent. | Price per Pound of Tungstic Acid, Cents. |
|---|---|---|---|
| 1– 4..... | 5–11 | 35–39 | 28 |
| 5– 9..... | 15–19 | 40–44 | 29 |
| 10–14..... | 20 | 45–49 | 30 |
| 15–19..... | 23 | 50–54 | 32 |
| 20–24..... | 25 | 55–59 | 34 |
| 25–29..... | 26 | 60 | 37½ |
| 30–34..... | 27 | ..... | ..... |

Prices in 1911 averaged about $6 per unit, whereas in 1912 prices had risen and were quoted at the end of the year as high as $8 per unit. The smaller demand for ferro-tungsten in the steel business continued, and accounts largely for the lack of activity in this industry.

The imports of tungsten and ferro-tungsten in 1912 were 287.81 tons valued at $323,872. This metal is dutiable at 20 per cent. ad valorem. Compared with the imports of the preceding fiscal year, these were 294.5 tons valued at $368,618; in the last half of 1911 the imports were 53 tons valued at $64,021.

[1] R. D. George, State Geologist, Boulder, Colorado.

In the United States the price paid to the miner in 1912, while higher than that of 1911, was not satisfactory. The deposits appear to be ample in number and development to supply any demand which may arise in 1913. The maximum production occurred in 1910; in the preceding year prices were much lower. In that year the expenditure for development and production as reported to the Census Bureau, for 116 small mines, was $365,780 and the value of the output was $614,370. It is known that stocks of concentrates are stored in quantity.

*Colorado.*—The largest production of tungsten ore comes from Colorado, and the ore is ferberite. The mines are in Boulder County and the largest operators in 1912 were the Primos Mining & Milling Company and the Wolf Tongue Mining Company. None of the many localities where tungsten ores have been found, outside of Boulder, has proved steadily productive so far.[1]

The Wolf Tongue Mining Company works its properties on a leasing system. The lessees are given the benefit of half the cost of shafts sunk by the company and are also furnished with electric hoists. Power costs them $20 per month; they pay a 25 per cent. royalty. The company is in a very favorable position to command a market. The Wolf Tongue Mining Company has recently arranged for the purchase of 70 patented claims and a mill, from D. H. Smith, Beaver Creek, Colorado. The company also enlarged its Nederland mill. The Primos Mining & Milling Company mines ores for its own purposes and does not sell in the market. The Conger mine of this company is being explored to a depth of 1000 ft., and is expected to open up many small veins. Practically all the other mines are shallow and worked on a small scale. A 6-mile tramway is being constructed at the Conger, connecting with the company's mill at Lakewood, and by a branch with the Quaker mine near Primos. The Conger is supposed to have produced $2,000,000 worth of ore. Continuity of the ore deposits in depth seems assured. The Boulder Tungsten Production Company has proposed a drainage tunnel to drain the district. This tunnel will also be a cross-cut tunnel for deeper workings at 600 to 1100 ft. Its length will probably be 2 miles, and the transportation will be greatly improved by such a tunnel.

*Other States.*—In California the Atolia field at the north edge of San Bernardino County, is controlled by the Atolia Mining Company. The ore is scheelite and this company was the largest producer of this mineral in the United States. Scheelite is also mined in the Stringer district, a few miles northwest of Atolia. A discovery of scheelite was reported from the west of Rand Mountains. In the east of San Bernardino County, a small tonnage of mixed tungsten ore (wolframite and scheel-

[1] Geo. E. Collins, *Eng. and Min. Journ.*, January 11, 1913.

ite), was shipped. The Placer Gold Company installed a new plant for extracting gold and tungsten from gravel in Kern Co.

In Arizona a few tons of hubnerite was obtained from dry placers. Ore was also mined from veins near Dragoon. Hubnerite ore was shipped from Arivaca to Denver for concentration. Scheelite ore which is associated with gold and silver ores at Oracle, was concentrated and shipped in small quantities. In Nevada small shipments of hubnerite came from Osceola and from Round Mountain. In Idaho, Patterson Creek furnished similar ore. Experiments on concentration were made at Loon Lake, Washington. A small shipment of wolframite is reported from Lordsburg, New Mexico. The Wasp No. 2 mine, South Dakota, formerly produced considerable tungsten ore carrying $500 in gold.

## Foreign Countries

*Argentina.*—Ores occur at St. Thomas and Santa Barbara. Shipments have been made to Germany in recent years. The exports in 1911 were 584 tons of tungsten ore.

*Australia.*—The wolframite exported from Australia in 1912 amounted to 20,428 cwt. valued at £97,647. The production from New South Wales was 283.1 tons, valued at £29,991 in 1911, and 171.8 tons valued at £16,584 in 1912. The scheelite produced was 108.45 tons valued at £11,342 in 1911, and 55.9 tons valued at £4963 in 1912. The production of Queensland was as follows: Wolframite, 1911, 539.4 tons valued at £54,163; 1912, 626.5 tons valued at £57,821. The scheelite produced in 1911 was 5 tons valued at £394. The scheelite production of 1912 was nil. The bismuth and tungsten ore was 129 tons valued at £11,564 in 1911, and 191.5 tons valued at £16,426 in 1912. The scheelite exported from New Zealand in 1912 was 135 tons valued at £13,347. The scheelite exported during the year 1911 from New Zealand amounted to 138 tons, valued at £11,853, as compared with 143 tons, valued at £15,070 in 1910. The principal sources in 1911 were Glenorchy, at the head of Lake Wakatipu, and Macrae's (Otago). Tasmania produced wolframite amounting to 66.49 tons, valued at £6601 in 1912

Victoria.—The Benambra Wolfram Syndicate, from its mineral lease 2536 at Mount Murphy, north of Omeo, obtained 17 1/4 tons of concentrates valued at £1070 in 1911.

Queensland.—The rich surface at Wolfram Camp is exhausted and only tributers are working, and there are no new discoveries. The same applies to Banford. The Irvinebank Mining Company has withdrawn. It is intended by three of the larger mining companies to develop only deeper ground. In the Larkin Mine, property of the Irvinebank Com-

pany, an ore pipe followed down to the depth of 100 ft. and a shoot was disclosed, averaging not less than 4 per cent. of concentrate. The present vertical shaft it is expected to cross-cut to the ore body at a depth of 160 ft. This mine has maintained a monthly output of 1 1/2 tons of molybdenite and 3 3/4 tons of wolfram.

Adjoining the Larkin Mine is the Murphy & Geaney. This mine has produced in the last three years, 150 tons of wolfram and 100 tons of bismuth. A new vertical shaft is to replace the old one and is now being sunk, and at a depth of 150 ft. will cut the continuation of the lode which contained rich ore in the bottom. The same lode is also to be intercepted by a shaft now being sunk at Leisner's Block. The intersection is supposed to be at 400 ft. Mr. Ball in his monograph on "Occurrence of the Rare Metals in Queensland," states that the dip of the ore is very irregular, so that the ore may have to be found by cross-cuts which will intersect shoots which are numerous. The method of prospecting has been entirely by sinking, and no diamond drilling has been done.

It is estimated that there are 60,000 tons of accumulations from previous mining operations, and a French company is erecting extensive works for the treatment of this waste. This company is expected to be a large buyer of low grade ores. The company will be well supported if it succeeds in separating the three metals.

At Mount Carbine, the Irvinebank Company is able to attack the mining problem in a systematic manner, and while the deposits are fissure veins confined to a limited area, the simplicity of the treatment will simplify the mining. Wolfram is the only product of the mines, and for the last eighteen months the output has been five tons per week, and the grade averaged regularly 1 1/2 per cent. wolfram. The concentration is accomplished by 10 stamps and Card tables, Krupp tables, and Luhrig vanners. It is intended to increase the crushing capacity and to reduce the cost. Development work in the mines is not sufficiently advanced. In order to make the undertaking a permanent one, water under pressure will have to be brought eight miles from McLeod Falls.

The production in 1912 has therefore been derived from Chillagoe and Herberton, although small parcels of wolfram continue to be mined at Fossilbrook, the Tate and Lynd Rivers, and at Emuford.

*Austria.*—The production of tungsten ore in 1911 was 45.4 tons valued at 79,245 crowns.

*Bolivia.*—The deposits of wolframite are found in the province of Caluyo, Department of La Paz. Although many mines have been shut down on account of fluctuations in prices, the exports of tungsten ore continue to increase. In recent years the average tungsten ore reduced to 63 per cent. $WO_3$, was as follows:

| Years. | Kgs. | Dollars. |
|---|---|---|
| 1908 | 169,637 | 41,412 |
| 1909 | 169,866 | 38,233 |
| 1910 | 210,061 | 56,651 |
| 1911 | 297,272 | 92,475 |
| 1912 | 472,457 | 118,094 |

*Canada.*—Scheelite Camp, in the central part of Halifax County Nova Scotia, is 12 miles from the Atlantic Coast but 34 miles from the nearest railroad point. The tungsten ore veins occur in the same formation as the old Moose River gold mines, which are 2 miles distant. The scheelite veins, in fact, have been prospected for gold, but nothing more than a trace has been found. The vein matter consists of quartz, scheelite, ankerite and arsenopyrite. The scheelite seems to be a primary deposit. No other tungsten minerals are found, and the ankerite would appear to contain the very element necessary to form wolframite. Development work began in 1909, the construction of a concentrating plant being undertaken in 1911. No production is stated.

*Federated Malay States.*—The exports of wolframite are increasing. In 1911, 2816 pikuls were exported and in 1912, 3755 pikuls. Ores from Burma were imported and treated by two plants.

*France.*—The production of France in 1911, was from 2 mines and amounted to 146 tons valued at 419,717 francs at the mine.

*Germany.*—Germany produced tungsten ores in Saxony. The uranium and tungsten ores are reported together and the separate production for recent years is not known. The tungsten ore exported to the United States from Magdeburg, Germany, during 1910, was $12,423; in 1911, $1132.

*India.*—During the year 1911, a considerable increase in the wolframite output occurred. This was especially due to Tavoy. The output in 1910 was 395 tons, and in 1911 was 1308 tons valued at £99,989. Not a single mining lease had been granted up to the end of the year 1911, but extensive mining operations were carried on nevertheless. No detailed reports are available of the wolframite obtained at Mawchi in the Southern Shan States, but these figures are included in those for tin, the metals not being separated locally. Wolframite exports from Burma, India, in 1912 were 1862 short tons valued $698,185; 995 short tons were exported in 1911. Burma exported through Rangoon wolframite to the value of $165,303 in 1911 and $293,925 in 1912. The wolfram mines are prosperous, and the industry established. Radcliff & Co., of Rangoon, estimated the percentage of $WO_3$, usually contained in the exported Burma product, at about 65 per cent.

*Japan.*—The tungsten ore produced in Japan during 1911, was 119

tons. The scheelite production of Nagasaki consular district for 1911, is reported,[1] as 82,945 lb. valued at $11,448.

*Norway.*—Tungsten ores are being worked in Örsdal near Egersund, in the southern part of Norway. The output in 1911 was about 6 tons, and the exports in 1912 were about the same. The mine is worked by the Christiania Minekompani.

*Peru.*—Peru produced tungsten ores (hubnerite) in recent years, as reported by the Director of the Institute of Mining Engineers, at Lima. The production was 12 tons in 1910, 48 1/2 tons in 1911. Output came from the Sociedad Minera Pelagatos and from Negociación Wolfram, in Pallasca (Ancachs). The Conchuchos Tungsten Co. will also work in the same region.

*United Kingdom.*—The average percentage of tungsten in Cornish wolframite in 1911, was 64. Most of this ore is obtained from the mines although a small quantity is also obtained from "stream works" treating tailings. The largest producer was the South Crofty, Ltd., at Carn Brea, producing 147.4 tons during 1911, valued at £14,732. The East Pool and Agar United Mining Co. at Illogan, and the Carn Brea and Tincroft Mines, Ltd., and the Parkanchy, at Scorrier, were the next largest producers. Other producers were the Gorland Wheal, at St. Day, Cornwall, and the Carrock Fell, Troutbeck, Cumberland. The total value of the tungsten ore produced in the United Kingdom in 1911, was 266 tons of which 254 tons was valued at £24,629. The production in 1912 was 189 tons. In treating the complex tin ores by new methods as at the Lough borough mill, wolframite is separated as a product for market on Ruthenburg magnetic separators. For further details see article on Progress in Ore Dressing in this volume.

The following table shows the production in recent years in foreign countries:

(In Metric Tons.)

| Country. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|
| Argentina | 497 | 817 | 1,912 | (*b*)584 | (*a*) |
| Australasia: | | | | | |
| New South Wales | 244 | 325 | 321 | 398 | 232 |
| Queensland | 426 | 617 | 873 | 553 | 637 |
| Tasmania | 5 | 29 | 68 | 71 | 68 |
| New Zealand | 88 | 79 | 179 | 140 | 137 |
| Austria | 40 | 39 | 40 | 45 | ..... |
| Bolivia | 170 | 152 | 210 | (*b*)297 | 472 |
| England | 237 | 382 | 278 | 264 | 192 |
| France | 113 | 54 | 30 | 146 | ..... |
| Germany (Saxony) | 42 | 96 | 95 | 100 | ..... |
| India | ..... | ..... | 400 | 1,329 | ..... |
| Peru | ..... | ..... | 12 | 12 | 49 |
| Portugal | 106 | 673 | 948 | 902 | 1,228 |
| Spain | 226 | 129 | 153 | 96 | (*a*) |
| United States | 599 | 1,469 | 1,833 | 1,173 | 1,152 |

(*a*) Statistics not available. (*b*) Exports.

[1] Carl F. Deichman, *Dly. Consls. and Tr. Rep.*, Oct. 14, 1912

## Technology

*Ductile Tungsten.*—Drawn wire can now be purchased in the open market. Formerly a powder made into a paste was used for lamp filaments, squeezed through a die and the particles welded by current which also drove off the binding material used. There are possibilities for high temperature laboratory furnaces on account of the high resistance and high melting-point, and temperatures higher than the platinum wound furnaces can be obtained. As the metal oxidizes at high temperatures an atmosphere of hydrogen must surround the wires.

*Properties of Tungsten.*[1]—Its density is 19.3 to 20.2; tensile strength 322 to 427 kg. per sq. mm.; coefficient of expansion, $4.3 \times 10^{-6}$; specific heat, 0.0358; hardness, Moh's scale, 4.5 to 8.0; melting-point, 3100° C.+. The ductile metal is practically insoluble in all common acids, and it can be drawn to a thinner wire than can any other metal. Tungsten gauze has been used as a filter in the laboratory, and is recommended for use commercially, *e.g.*, for filtering electrolytic slime in refineries.

It is well suited for standard weights. Acid-proof dishes and tubes have been made for laboratory use; because of its great ductility it is well adapted for galvanometer suspensions, and for cross hairs in scientific apparatus; and because of the same property it is recommended for use in surgery. Tungsten resistors are of two types, tungsten wire helix on an aluminum tube, sealed in a hydrogen atmosphere; and a tungsten tube, replacing the carbon tube in an Arsem vacuum furnace. The tungsten-molybdenum couple is used in thermo-electric work; its electromotive force increases to about 12 1/2 millivolts at 540° C., then decreases to 0 at 1300° C. Owing to its elasticity and paramagnetic properties, it could be used in electric measuring devices, watch springs, etc.

The cost of pure tungsten is $10 to $12 per pound.

*Production of Ductile Tungsten.*[2]—The brittle tungsten should be entirely free from oxide, iron and nickel, practically free from non-metallic impurities such as sulphur, phosphorus, etc., and should not contain more than about 0.1 per cent. of carbon. It is desirable that the metal be dense, sintered almost to melting point before working, and the actual swaging and drawing should be carried out gradually avoiding exposure to air.

In order to get a pure metal, it is desirable to purify the trioxide, which is done by reducing it to the dioxide, volatilizing the latter as oxychloride, and treating this with hydrochloric acid. In this way silica and phosphoric acid are left behind in the non-volatile residue, while

[1] C. G. Fink, *Eighth International Congress of Applied Chemistry.*
[2] *Zeit. f. angew, Chem.*, p. 1889, 1912; abst. *Journ. Soc. Chem. Ind.*, Oct. 15, 1912.)

arsenic and antimony pass into solution in the hydrochloric acid. The pure trioxide is reduced in a rapid current of hydrogen at a temperature of 1250° C., so as to produce the metal in a sufficiently coarse state of subdivision and relatively free from oxide. After it has been pressed into rods, the latter are hardened by heating in hydrogen to about 1300° C., and sintered by heating in a special furnace to about 2650° C. In the case of very pure tungsten, it may be necessary to add a little (about 0.05 per cent.) carbon to lower the melting-point.

It is found that the pure metal melts at about 2900° C., whereas in the presence of carbon the melting-point may be as low as 2730° C. There is a diminution in volume, on sintering, of about 14 per cent.

*Drawn Wire.*[1]—After repeated swagings and heatings, the metal becomes ductile, the metal is rolled, and the rolled bars are drawn into wire. No annealing is required between drawings, although annealing is often performed, as it saves wear on the dies.

The strength manifested by small wires was extraordinary. A wire of 0.1 mm. diameter had a strength of 180 tons per square inch, while one of 0.0167 mm. in diameter showed 380 tons per square inch. The size of the wire was deduced from its weight. The metal in these wires contained no carbon, as it was reduced from pure $W_2O_3$, and the greatest care was taken to prevent subsequent contact with carbon. If any carbon was present in the metal, the powder would not adhere under pressure.

*New Uses.*—On account of the high surface tension, the metal is well adapted for sparking or arcing terminals. In some of the newer Crookes or X-ray tubes which are designed to work at enormous intensities, being capable of absorbing 10 kw. and taking "snap-shot" skiagraphs of even the thickest parts of the human body, tungsten has been used as the anode target for the cathode rays, being backed up with copper to convey away the heat developed. Although rendered molten by even this instantaneous impact of electrons, the great surface tension of the tungsten prevents its loss or change of shape. Tungsten electrodes have also been used for gas-engine spark gaps and show longer life than those of other metals of equivalent cost.

The applications of metallic tungsten are described by W. D. Coolidge,[2]

*Fire Proofing of Cotton Cloth.*—This is accomplished by a solution of 3 parts ammonium phosphate, 2 parts ammonium sulphate and 40 parts water or by means of a solution of sodium tungstate. Many other mixtures answer the same purpose but they all give only temporary results, as the solutions dissolve out in washing. The process of W. H.

[1] Alexander Siemens, Inst. of Metals, March, 1913.
[2] Twenty-ninth Annual Convention of American Engineers, Boston, June 25, 1912.

Perkins consists of treating the fiber with sodium stanmate of 45° Tw. removing excess and drying thoroughly on heated copper drums. A solution of ammonium sulphate of 15° Tw. is then applied, the material washed and dried.

*Treatment of Tungsten concentrates.*[1] After the wolframite has been separated fuse with sodium-carbonate, adding nitrate. This is usually done on a hearth of dolomite agglomerated with tar and burned in place in a reverberatory furnace. The fused mass is broken up and digested with boiling water; to the solution which contains the silico-tungstate and the phospho-tungstate of sodium, hydrochloric acid is added, forming para-tungstate, $5Na_2O.12WO_3$, soluble in hot solution but precipitated in cold. The para-tungstate is filtered off and transformed back again to the normal tungstate by adding sodium-hydroxide. Tungstic acid is then obtained from this solution by adding hydrochloric acid while boiling. This process uses large quantities of reagents, and there is also a loss on account of solubility of the para-tungstate.

Other processes heat with calcium carbonate and sodium chloride, or with magnesium chloride or potassium bisulphate.

Tungstic acid may be prepared from scheelite, by forming an insoluble residue with the addition of hydrochloric or nitric acid, or by fusing with potassium fluoride, producing a soluble alkaline tungstate, or by forming $WOCl_4$, by means of ferric chloride. The latter compound decomposes with water, precipitating the tungstic acid.

In the manufacture of metallic tungsten and ferro-tungsten, the concentrate consisting of 60 to 70 per cent. trioxide, is mixed with soda-ash and roasted for 4 hours. It is then leached and filter-pressed, leaving sodium tungstate in the press, the liquor being treated with hydrochloric acid to precipitate yellow oxide. After drying this oxide it is reduced to powder containing 99.25 to 99.50 per cent. metal, with 0.50 to 0.15 carbon. The density is from 19 to 19.25. In the manufacture of ferro-tungsten, the concentrates are sometimes treated with steel, graphite and flux in crucible furnaces, at a high heat. In this way alloys of less than 80 per cent. tungsten can be obtained. The higher grade alloys are preferably manufactured in the electric furnace directly from concentrates and steel.

*The Uses of Tungsten Compounds.*—Sodium tungstate is used in large quantities for fireproofing, cloth and draperies, and as a mordant in dyeing. Sodium-tungstate has been used to seal platinum apparatus, on account of its similar coefficient of expansion at low temperatures. Other tungsten salts are used for weighting silks and as a mordant.

[1] Abstract from "The Chemistry of Tungsten," by Chas. Baskerville, Ph. D., *Met. and Chem. Eng.*, June, 1913.

Tungsten compounds have also been used in glass and porcelain coloring and in making bronze colors. Tungsten bronze is made by dissolving tungsten trioxide in melted sodium-tungstate. Cadmium borotungstate has been used for the mechanical separation of minerals (sp. gr. 3.28).

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# URANIUM AND VANADIUM

The production of uranium and vanadium ores in the United States as in previous years, is mostly from southwestern Colorado and southeastern Utah. The uranium-bearing ores are practically all carnotite. The percentage of uranium oxide ($U_3O_8$) in the ore varied from 0.5 to 6.32, while the percentage of vanadium oxide ($V_2O_5$) was from 1.42 to 13.63. The proportion of the two oxides is extremely variable. Pitchblende was mined near Central City, Colorado, on a small scale and chiefly used as specimens. The ores of vanadium are the mica roscoelite, which was mined near Newmire, San Miguel County, Colo. The iron vanadate obtained from this ore by the Primos Chemical Company is shipped east to be smelted into ferro-vanadium. As far as is known, no vanadinite was mined in the United States.

The ores containing uranium are much sought for their radium contents, and the radium is generally proportional to the uranium. The basis of settlement for such ores is, therefore, on the uranium oxide content. Prices were considered low by the producers and ranged from $1.30 per pound to $1.50 per pound of $U_3O_8$. This applies where the uranium oxide exceeded 2 1/2 per cent. For the vanadium ores the settlement was on a basis of about 25 to 30 cents a pound for vanadium oxide. In the form of metal the price of vanadium was lower than in previous years, and ranged from $2.50 to $3.25 per pound of vanadium contents. The use of ferro-vanadium, especially in America, appears to be extending. The price in Europe is regarded as high, and is said to limit the use of ferro-vanadium. Three years ago a price of 25s. a pound confined the use of vanadium to forging or spring steel, and owing to the very small quantities required this metal could compete with nickel of which 3 per cent. of the steel was required. Over 75 per cent. of the best high-speed tool steels now manufactured in Sheffield are treated with vanadium. The price of the metal is supposed to be at a low point and is not likely to be reduced. The largest producer in America is the Vanadium Company of America, which at present has practically no competition. It is estimated that this company in 1912 treated more than 600 tons of ore in manufacturing the alloy. It is stated that in the United States in 1912, 90,000 tons of steel were treated with vanadium. In 1905 the output of vanadium steel was 800 tons. Seven pounds of vanadium have therefore been used for a ton of finished steel.

The shipments of carnotite from the United States, mostly to Liverpool, probably did not exceed 200 tons in 1912. Some vanadinite ores were also shipped from Mexico and the Southwest to the same European plants where the Australian and Spanish ores are treated in small amounts. The imports of ferro-vanadium into the United States were insignificant in 1911, and nil in 1912. The imports of uranium oxide and salts of uranium in recent fiscal years were valued as follows:

| | Dollars |
|---|---|
| 1908 | 6,789 |
| 1909 | 9,628 |
| 1910 | 8,402 |
| 1911 | 12,651 |
| 1912 | 15,024 |

## UNITED STATES

*Colorado.*—The shippers of vanadium ore from Placerville are the Standard Chemical Company, Curran & Hudson, and the Primos Chemical Company (Newmire). The Paradox district has a wagon haul of 50 to 75 miles, hence high-grade ores are transported. The ores in this district contain little uranium.

The sandstone deposits near Placerville, Colorado, are described by Frank L. Hess.[1]

Placerville is in San Miguel County, southwestern Colorado, on the east side of the San Miguel Valley, which is 1500 ft. below the mesa.

The individual deposits are described by Herman Fleck and Sidney W. French.[2]

The sediments are of Jurassic and Triassic age. The lowest or Dolores formation consist of sandstone, grits, conglomerates, and arkoses, mostly reddish, of about 600 ft. thickness. Above this lies the La Plata sandstone, which is light colored with a 1 to 10-ft. bed of limestone between. In most places where the vanadium occurs in this lower sandstone of the La Plata, the portion above an unconformity is yellowish and that below is almost white, and probably two-thirds of the sandstone down from the limestone bed is cross-bedded and about 60 ft. in thickness where the vanadium deposits occur. In some cases dikes are near the ore deposit, as near Sawpit, which is 4 miles up the river from Placerville.

The known deposits of this region extend through a distance of a little more than 9 miles. In appearance most of the vanadium-bearing rock is a dull green to almost black, fine, even-grained sandstone. In some places the color darkens with the percentage of vanadium, but some coloring is also due to iron oxides and organic matter. In other places

[1] *U. S. Geol. Surv., Bulletin* 530, p. 142.
[2] *Colorado School of Mines Quart.*, January, 1909.

the carnotite makes the color slightly yellowish-green. In thickness the deposits range from 1 to 2 in. to over 30 in. The richest ore is always near the seam indicating an unconformity. In the deposits of the Primos Chemical Company, on the east side of Bear Creek, and which are very thick, three such seams exist locally. The richest ore near the seam may be thin and is composed of roscoelite, quartz, and a little pyrite, being practically a vein from which the country rock has been impregnated. The deposits have been eroded, and were more extensive at one time. At present they consist practically of flat lenses 600 to 700 ft. long, with local thickening. The cross-section of the deposit on the Rio No. 1 claim just south of Fall Creek is as follows:

| | Inches. |
|---|---|
| Sandstone, somewhat iron stained, part quartzite | 3 |
| Dark vanadiferous sandstone | 4 |
| "Bone" quartzite | 2 1/2 |
| Dark vanadiferous sandstone | 4 1/2 |
| Dark vanadiferous sandstone | 3 1/2 |
| "Bone" quartzite | 2 1/2 |
| Bottom of drift | |

Pyrite is found scattered in the ore in minute grains, and is to some extent oxidized, showing in rusty spots. Secondary depositions of yellow carnotite in joints have evidently been leached from the ore-bearing rock. The amount of carnotite is irregular, being small in the vanadium ore on Bear Creek and larger and more irregularly distributed in the deposits east of Placerville. The ore from Bear Creek also shows a trace of uranium. From the vanadium deposits along both sides of Fall Creek extend lighter bright green deposits containing no more than a trace of $V_2O_5$, but in places the middle part where dull green such extensions may contain from 2 to 3 per cent. $V_2O_5$. The lighter green is due to chromium mica, and the miners call this "chromite" sandstone. On the west side of lower Leopard Creek chromium stains reach 10 ft. in thickness although there is very little vanadium present.

The chromium mineral and stains are supposed to be due to the decomposition of an original vanadium mineral, brought in by solutions. The deposits of several areas having in some cases copper stains instead of chromium, may, therefore, be due to similar origin.

The transportation from this district is from the Rio Grande Southern Railroad, which is a narrow-gage line.

The primos Chemical Co. operates the reduction plant at Newmire built by the Vanadium Alloys Co. in 1905. The ores are concentrated and therefore this company can ship with a minimum freight rate. In 1911 the General Vanadium Company and the Standard Chemical Co. also mined and bought carnotite ores from the Paradox Valley, shipping them through Placerville. The General Vanadium Co. ships its ore to Liverpool, and the ores must therefore be high grade, not less than 3 per

cent. metallic vanadium. The average vanadium contents of ores near Placerville is much lower. More than half the samples collected along Leopard Creek gave less than 1 per cent. About one-fourth gave 1 or 2 per cent., and one-seventh gave more than 2 per cent. A specimen which was probably a piece of roscoelite vein, in very dark green sandstone from Bear Creek, showed 8.3 per cent. vanadium. It is safe to say that there are many thousand tons of sandstone that will show between 1 and 2 per cent. vanadium, and many thousands more which will show between 1/2 and 1 per cent. The material therefore requires treatment on the ground as is done by the Primos Chemical Company.

*New Mexico.*—Promising deposits of molybdenum have been discovered near Magdalena, New Mexico. Eight feet of vein matter in the Silver Line Mine contain scattered crystals of wulfenite and vanadinite.

Vanadium deposits in New Mexico in the Sierra de los Caballos have been described by Frank L. Hess.[1]

The vanadium-bearing veins lie at Palomas Gap and 3/4 mile south. They occupy fissures in limestone and are associated with minerals such as galena, vanadinite and malachite. The Vanadium Mines Company is working two veins, both developed by shafts. The vanadinite which predominates in the rich ore is sometimes in crystals of 1/8 in. in diameter. The ore is a pinkish clay. Nothing definite is known as to the richness of the ores. Veins of lead-bearing minerals about 1 1/2 miles south do not carry vanadium,[2] but they have the same gangue minerals and cut the same country rock. These veins carry wulfenite.

*Pennsylvania.*—Carnotite has been discovered by Edgar T. Wherry near Mauch Chunk, Carbon County, Penn.[3]

The mineral and its occurrence is similar to that of the Colorado and Australian carnotite. It is believed that the mechanical concentration of dark minerals from conglomerates, etc., has resulted, following the change from arid to moist climatic conditions at the beginning of Pennsylvanian time. It is suggested that the frequent association of uranium and vanadium with coal may also be connected with these changes.

*Utah.*—The carnotite near Green River, Utah, on the east side of the San Rafael Swell is described by Frank L. Hess.[4]

The east wall of the valley, rises 300 ft. above the bottom, and the formation containing the deposit is equivalent to the one lying above the LaPlata sandstone, at Placerville, Colorado, namely the McElmo. During 1911 a carload of ore was shipped to Europe by V. C. Ward and

[1] *Bulletin* 530, *U. S. Geol. Surv.*, 1913.
[2] P. A. Larsh, "The Ore Deposits of New Mexico," Prof. Paper, *U. S. Geol. Surv.*, No. 68, 1910, p. 118.
[3] *Amer. Journ. of Sci.*, June, 1912.
[4] *Bulletin* 530, *U. S. Geol. Surv.*, 1913.

associates, and is reported to have sold on a combined basis of 6.11 per cent. of the oxides of uranium and vanadium, 2.24 per cent. $U_3O_8$ and 3.87 per cent. $V_2O_5$. The preliminary tests had indicated that the percentage of oxides was 2.52 and 4.80 respectively. Other claims from which small amounts of ore have been taken were the Little Bessie and Little Vernon. Also 1/2 mile south of the Wardvern claim is the Little Hulda. The latter shows no organic remains, as do other deposits. Light stains show through 1 ft. of rock, but only 2 or 3 in. next to a slickensided fault contains much carnotite.

In these deposits no vanadium minerals that do not carry uranium, no chromium or copper minerals, and no asphalt have yet been found. The predominating minerals are carnotite and iron oxide, with a few quartz veins. The organic matter provides by its decay convenient cavities for mineralization. Only one of the deposits is accompanied by faults.

Deposits of uranium occur further south near Fruita.

The vanadium deposits near Richardson, Utah., have been described by Boutwell.[1]

The deposit is not being worked. It consists of thin patches 1 to 10 in. in diameter, upon the walls of sandstone blocks being more abundant near the main fissure. The mineralization is through replacement for a distance of about 4 ft. from the main fracture. Yellow earthy carnotite up to 1 in. in diameter, is found in some of the beds of gray sandstone, particularly upon the hanging wall.

## Foreign Countries

The only vanadium ores of practical importance are vanadinite, patronite, carnotite, and roscoelite. Vanadinite ores derived from the Spanish province of Estremadura, have been worked since 1899. Patronite is a sulphide of vanadium associated with pyrite and carbonaceous matter, containing about 30 per cent. of $V_2O_5$. The deposits at Minas Ragras, in Peru, are the only source and are owned by the American Vanadium Company of Pittsburgh. The whole output is shipped from Callas to Bridgeville. At the present time 75 per cent. of the world's vanadium output is from this source.

Until recently the largest amount of uranium and radium was produced from Joachimsthal nickeliferous and cobaltiferous pitchblende. Irregular amounts were also produced from Cornwall and Devon, while Norway has two deposits of fergusonite rich in uranium.

*Argentina.*—Exports of vanadium ore were 217 tons in 1911.

[1] *Bulletin of the U. S. Geol. Surv.*, 260, 1904, pp. 200 to 210.

*Austria.*—The uranium ore produced at Joachimsthal was 9 metric tons in 1908, 13 tons in 1909, 65 tons in 1910, and 5.7 tons in 1911. The uranium salts produced amounted to 8.4, 10.2, 10.3 and 6.8 tons respectively in these years. The market for uranium colors does not appear to be expanding.

*Peru.*—The vanadium ore produced in Peru as reported by the Director of the Institute of mining engineers in Peru, was 1749 tons in 1909, 3130 tons in 1910, and 2251 tons in 1911. The vanadium exported from Peru to the United States, through Callao and other consular agencies, was valued at $78,107 in 1911.[1]

The total exports to all countries in 1909 was valued $340,469.

*Portugal.*—Uranium ores were not mined before 1908. Many companies have been formed since 1906. The provinces of Minho, Tras-os-Montes and Beira are in a granite region containing the mineral zone. The richest district, however, is on the southern edge of the granite area, between the towns of Guarda and Savugal. Here the veins outcrop in Cambrian strata, and contain wolframite.

In the district of Villar-Formoso, ore is found in the granite as well as the schists. The ores are autunite and chalcolite. The autunite is accompanied by uranocircite (calcium replaced by barium). Along the outcrops patches of ore assay 4 to 5 per cent. uranium. The workings of the Uranium Company have confirmed a uniform extent of ore, running 2 per cent. The lower limit of payable ores may be stated as 1/2 per cent. The Uranium Co. employs 600 men at Baracao. The treatment of the ore is chemical without previous concentration.

The uranium ore, etc., produced in Portugal according to official figures, is as follows: 1910, 138,000 kg.; 1911, 813,700 kg.; 1912, 956,660 kg. The Rosmaneira mine was the only one operating in 1911. The production was uranium oxide ($U_3O_8$), 3.6 tons; milled ore, 460.2 tons; uranium sulphate, 1.4 tons; slimes, 348.5 tons. The values of these products was £3200, £1124, £324, £1413 respectively. The production in 1912 was 956.660 tons of all products. The uranium sulphate mentioned contains much barium sulphate that is radioactive.

*United Kingdom.*—The Trenwith Mine, St. Ives, Cornwall, produced in 1912, 42 tons; in 1911, 67 tons, and in 1910, 76 tons of uranium ore.

## Technology

The chief use of vanadium is in the treatment of steel. Vanadium is a more common constituent of pig iron than is usually supposed.[2]

The Lehigh Valley pig irons carry from 0.02 to 0.05 per cent. of

[1] *Dly. Conslr. and Tr. Rep.*, Nov. 16, 1912.
[2] Porter Shimer, *Bull. A. I. M. E.*, August, 1912.

vanadium, and from 0.1 to 0.2 per cent. of titanium. These elements follow silicon; with high silicon and low sulphur the iron carries the maximum of these elements. In remelting, the loss may be 14 per cent. of the vanadium present. Vanadium irons show a dull dark gray patch in a white net-work. The iron is soft. The vanadium and titanium apparently do not alloy with the iron, crystallizing out as carbides.

The interest in uranium is due chiefly to its association with radium. The chief use has been in the manufacture of uranium oxide for coloring pottery and glass. Some uranium glasses contain as high as 20 per cent. $U_3O_8$. Experiments are being made in the application of uranium to steel.

*Metallic Vanadium.*—Vanadium analyzing over 99 per cent. V has been prepared by reducing $V_2O_3$ with either aluminum or with vanadium carbide.[1]

The metal is difficult to obtain on account of the tendency to form nitride, hydride and carbide.

*Vanadium Aluminum Alloys.*—According to Nicolas Czako,[2] alloys containing up to 10 per cent. V are malleable; from 20 to 25 per cent. V they can be pulverized in water; from 25 to 53 per cent. V, they are full of cavities and it is difficult to obtain a polished surface.

The composition AlV is the hardest; the hardness again increases to a point when the alloy contains 53 per cent. V. From 60 to 80 per cent. the hardness decreases and the mixture is free from blow-holes.

*Concentration of Carnotite.*—Siegfried Fischer[3] states that as carnotite occurs as a coating on other minerals, a slight crushing will allow the mineral to be floated off as slime. A flow-sheet of such a mill is described.

*Concentration of Pitchblende.*—A method found satisfactory in testing ores, has been described by Henry E. Wood,[4] 50 per cent. of the mineral is lost with crushing finer than 20 mesh. A 90 per cent. recovery of the pitchblende with a concentrate running 45 to 56 per cent. $U_3O_8$, has been obtained by the following steps: (1) Crushing to 20 mesh; (2) roasting to expel sulphur, converting $FeS_2$ into $Fe_3O_4$; (3) magnetic removal of the iron; (4) wet or dry separation of the non-magnetic portion.

Carnotite ores will yield to treatment by simply agitating 20-mesh ore in water, collecting the slime. Two tons can be concentrated into one, when the oxides of the original ore do not exceed 2 per cent. ($V_2O_3 + U_3O_4$) and with an efficiency of 75 per cent.

*Extraction of Uranium and Vanadium.*—Acid processes are unsatisfactory, as the metallic vanadates are gelatinous and cannot be washed.[5]

[1] *Journ. du Four Electrique*, Oct. 15, 1912.
[2] *Journ. du Four Electrique*, Feb. 1, 1913.
[3] *Met. and Chem. Eng.*, June, 1912.
[4] President, "Ore Testing Company," Denver, Colo.
[5] Siegfried Fischer, *Met. and Chem. Eng.*, August, 1912.

The use of alkalies is prohibitive as they combine with the gangue. If the ores can be first concentrated, separating the gangue, the alkali solution is mixed with the concentrate and evaporated to dryness at 200 to 300° C. The mass is then extracted, the solution neutralized with sulphuric acid, and the vanadium precipitated as ferrous vanadate. The residue is then available for uranium extraction.

A process for the extraction of vanadium from its ores is that of Bryamji D. Saklatwalla (U. S. pat. Nos. 1,020,224; 1,020,312, assigned to the American Vanadium Co.), who treats the ore with acid, preferably dilute sulphuric, and oxidizes the resulting solution with ammonium persulphate, sodium chlorate, or some similar salt, thereby throwing down the hydrated, red oxide of vanadium. Gaseous oxidizers can be used also; for instance, chlorine is said to be advantageous, as the solution from which the vanadium has been precipitated, if used for treatment of further ore, is especially potent in dissolving sulphides. The hydrated, red oxide is then dried, leaving $V_2O_5$ as a marketable product.

*Commercial Vanadium-acid Determination.*—Vanadic acid is furnished by the mining industry in large quantities and is used in making ferro-vanadium and vanadium alloys. In this vanadic acid the impurities amount to 15 to 20 per cent. These are either in minerals; iron, manganese oxides; in alumina, silica, arsenic, phosphorus, etc., or in the products of reactions in treatment, such as soda. When calcined for use the vanadic acid is not easily attacked by acid for analytical purposes. If lower oxides are present, heating to redness may cause a gain in weight before analysis. Prof. G. Chesneau[1] gives methods for commercial vanadic acid. He also gives a typical analysis:

| | |
|---|---|
| $V_2O_5$ vanadic acid | 84.9 per cent. |
| $Na_2O$ soda | 9.6 per cent. |
| $Fe_2O_3$ | 3.9 per cent. |
| $Mn_3O_4$ | 0.2 per cent. |
| CaO | 0.6 per cent. |
| MgO | trace |
| $SiO_2$ | 0.5 per cent. |
| $As_2O_5$ | 0.65 per cent. |
| $P_2O_5$ | 0.02 per cent. |
| Moisture | 0.2 per cent. |
| Gain in calcining | 0.3 per cent. |

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# ZINC

By W. R. Ingalls

The total production of spelter by ore-smelters in 1912 was 348,638 tons, of which 7447 tons was derived from galvanizers' dross, skimmings, scrap, etc., and the remainder from ore. The production from dross, scrap, etc., was 9030 tons in 1911 and 7793 tons in 1910. These data do not include the production of spelter by concerns which treat dross and scrap only; the output of such spelter was 11,350 short tons in 1910, 13,500 tons in 1911, and 12,000 tons in 1912.

I. PRODUCTION OF SPELTER IN THE UNITED STATES.

| States. | 1904. | 1905. | 1906. | 1907. | 1908. | 1909. | 1910.(c) | 1911.(c) | 1912. (c) |
|---|---|---|---|---|---|---|---|---|---|
| Colorado | 4,906 | 6,599 | 6,260 | 5,200 | 3,079 | 6,115 | 6,564 | 7,477 | 8,860 |
| Illinois (a) | 47,607 | 45,357 | 48,238 | 56,103 | 50,244 | 75,229 | 79,570 | 88,681 | 94,902 |
| Kansas | 103,721 | 114,948 | 129,741 | 133,561 | 99,136 | 103,390 | 105,697 | 106,173 | 111,761 |
| Missouri | 12,056 | 11,800 | 11,088 | 11,594 | 10,196 | 8,418 | 6,485 | | |
| Oklahoma | ..... | ..... | ..... | 5,094 | 14,867 | 28,840 | 34,760 | 46,333 | 76,837 |
| South and East (b) | 13,513 | 23,044 | 30,167 | 38,060 | 32,989 | 44,470 | 43,989 | 47,172 | 56,278 |
| Total tons of 2000lb. | 181,803 | 201,748 | 225,494 | 249,612 | 210,511 | 266,462 | 277,065 | 295,836 | 348,638 |
| Total tons of 2240lb. | 162,324 | 180,132 | 201,343 | 222,868 | 187,776 | 237,913 | 247,364 | 264,139 | 311,284 |
| Total metric tons | 164,921 | 183,014 | 204,548 | 226,398 | 190,933 | 241,730 | 251,348 | 268,378 | 316,368 |

(a) Up to 1903, inclusive, includes also the production of Indiana. (b) New Jersey, Pennsylvania and Virginia, and (since 1903) West Virginia. (c) From *Eng. and Min. Journ.*

The amount of the recovered spelter that should properly be counted statistically is uncertain. A good deal of scrap zinc is remelted in the manufacturing plants where it is made, *e.g.*, in every rolling mill, and such remelted zinc should not, of course, appear in any statistical enumeration. On the other hand certain smelters buy and redistill and subsequently sell as spelter, often of excellent quality, what was distinctly a waste product. This is obviously an addition to the new supply of spelter and should be recognized just as is that which the ore smelters recover from dross, skimmings, etc. In my estimate I have conformed to this reasoning.

Of the total spelter production of the ore-smelters in 1911, concerns using coal as fuel produced 119,989 tons, or about 40 per cent. of the total. In 1912 they produced 134,077 tons, which was only about 38 per cent. of the total. This result is, no doubt, contrary to preconceived ideas, so much having been heard about the troubles of the gas smelters in 1912.

Apparently the gas smelters ran as hard as they could, in order to take advantage of the favorable market conditions.

In addition to the spelter production there was an output of 492 tons of commercial zinc dust in 1912, against 254 tons in 1911. Two smelters are engaged in this business. The importations of zinc dust were about 2400 tons, against 1713 tons in 1911.

In 1910, 3398 tons of spelter were produced in bond. In 1911 the production in this way was 9598 tons and in 1912 it was 10,879 tons. The exports of bonded spelter are stated in an accompanying table.

II. PRODUCTION OF ZINC ORE IN THE UNITED STATES.
(In tons of 2000 lb.)

| State. | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|
| | Tons. | Tons. | Tons. | Tons. | Tons. (g) | Tons.(g) | Tons.(g) |
| Arizona | ..... | ..... | ..... | 7,908 | 7,568 | 6,395 | 11,937 |
| Arkansas | 4,200 | 4,088 | 2,582 | (d) 320 | 190 | 860 | 1,567 |
| California | ..... | ..... | ..... | ..... | ..... | 3,754 | 6,639 |
| Colorado | 114,000 | 142,510 | 85,052 | 90,288 | 77,065 | 158,528 | 212,423 |
| Idaho | 2,150 | 11,847 | 1,558 | 2,784 | 10,248 | 9,667 | 19,482 |
| Kentucky | 975 | 1,005 | 341 | (d) 94 | 179 | 575 | 947 |
| Mo.-Kan. | (a)280,260 | 297,126 | 273,420 | 304,581 | 289,913 | 268,500 | 289,177 |
| Montana | 4,900 | 1,218 | 2,783 | 12,037 | 33,514 | 56,593 | 34,034 |
| Nevada | 7,080 | 4,593 | 1,445 | 4,609 | 4,915 | 5,666 | 20,654 |
| New Mexico | 30,000 | 4,281 | 2,290 | 19,163 | 15,959 | 10,184 | 25,889 |
| New Jersey | 404,690 | 368,710 | 399,232 | 479,699 | (f) | (f) | (f) |
| Oklahoma | ..... | 3,240 | 9,300 | 17,089 | 1,640 | 8,750 | 4,325 |
| Tennessee | ..... | ..... | ..... | 1,710 | 2,775 | 3,439 | 6,635 |
| Utah | 10,700 | 9,043 | 709 | 18,130 | 27,318 | 19,933 | 24,539 |
| Wisconsin | 42,130 | 53,011 | 58,135 | 69,000 | 51,383 | 71,565 | 90,762 |
| Others | (e) 850 | (e) 2,241 | (e)1,530 | 572 | 46,905 | 44,896 | 56,099 |
| Totals | 905,175 | 902,923 | 838,377 | 1,027,984 | 569,572 | 669,305 | 805,109 |

(a) Production of Joplin district, plus output of southeastern Missouri, the latter as reported by the State mine inspector. (b) Report of State Geologist; crude ore. (c) Arizona, Nevada, Illinois, Iowa, Tennessee and Virginia. (d) These figures may be a little too low, there being a possibility that some ore originating in these States has been credited to other States, especially Missouri and Kansas. (e) Tennessee, Arizona and California. (f) Included in others. (g) The statistics for 1910 to 1912 include only the zinc ore received by producers of spelter, wherefore some apparently peculiar changes from the figures for previous years, which include the receipts by oxide manufacturers. Reports missing from three small smelters.

With the increase in the production of spelter in 1912, there was naturally an increase in the production of ore, which rose largely over the corresponding figures for 1911. The striking features of the ore statistics are the further increase in the production of Colorado, which was largely accounted for by Leadville calamine, and the important increases in a large number of the states west of the Rocky Mountains, such as Arizona, California, Idaho, Nevada and Utah. Calamine ores were in strong demand during 1912, because of the trouble at the gas smelters, less gas being needed in the smelting of these ores, which do not have to be roasted, than in the smelting of blendes. During the latter part of 1912 smelters were willing to take calamines at a margin of $13 @$15 a ton, when on blende they wanted $20 and more. Montana, instead of showing the expected increase, exhibited a decrease. This

was, of course, due to the troubles of the Butte & Superior Company, which now have apparently been rectified, wherefore there is but little doubt that the Montana statistics for 1913 will show a noteworthy advance.

The Joplin district gained over 1911, but only equaled the figures for 1910. The average price of spelter in 1912 was 6.8 cents per pound, against 5 3/8 cents per pound in 1910. It appears that even an unusually high price for spelter cannot raise the production of the Joplin district to as much as 300,000 tons.

The failure of the zinc mines of Arkansas to yield an output of importance was noted a good many years ago. It appears now that Oklahoma also is failing to come to the front. On the other hand, Wisconsin gains steadily. Tennessee made a handsome gain in 1912 and undoubtedly will do much better in 1913, inasmuch as the new mill of the American Zinc, Lead & Smelting Co. will be in operation during the latter half of this year. The output of zinc ore credited to "other states" is due chiefly to New Jersey.

The importations of zinc ore from Canada and Mexico run along at about the same figure every year, especially in the case of Mexico. The importation is very much less than before the tariff was imposed, but while these supplies are materially reduced, it is evident that our own mines are capable of making such additions as are required of them. A small tonnage of zinc ore was imported during 1912 from the far East.

III. IMPORTS OF ZINC ORE INTO THE UNITED STATES.
(In tons of 2000 lb.)

| Source. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|
| British Columbia.. | 1,157 | 6,157 | 10,024 | 11,795 | 2,356 | 9,707 |
| Mexico..... | (a)108,800 | 66,383 | 106,245 | 29,198 | 28,596 | 29,436 |
| Totals..... | 109,957 | 72,540 | 116,269 | 40,993 | 30,952 | 39,143 |

(a) The actual tonnage of ore imported was somewhat greater than this figure, but it included some mixed ore which for statistical purposes has been reduced to the zinc ore equivalent. This table is based on reports from the smelters of the ore received by them from these countries.

In 1912, there were seven zinc smelters who produced sulphuric acid, the American Zinc, Lead & Smelting Co. being an addition to the list. The statistics of the works of this class for the last three years are as follows:

IV. STATISTICS OF SPELTER-SULPHURIC ACID WORKS.
(In tons of 2000 lb.)

| | 1910. | 1911. | 1912. |
|---|---|---|---|
| Ore received..... | ..... | ..... | 287,205 |
| Spelter produced..... | 100,791 | 115,310 | 127,655 |
| Sulphuric acid produced basis 60°..... | 202,000 | 252,192 | 262,555 |

As in the previous year the smelters who made sulphuric acid drew their main ore supply from the Joplin district and Wisconsin, but it is noteworthy that some of these smelters now use a good deal of Western ore. In 1911 they received 107,995 tons of blende from the Joplin district and 71,168 tons from Wisconsin. In 1912 they obtained 117,806 tons from Joplin and 87,676 tons from Wisconsin.

The total stock of spelter at smelters' works at the end of 1912 was 4264 tons, against 9323 at the end of 1911 and 23,000 tons at the end of 1910. The deliveries into consumption are computed in the accompanying table.

V. DELIVERIES OF SPELTER IN THE UNITED STATES.
(In tons of 2000 lb.)

| | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. | 1912. |
|---|---|---|---|---|---|---|---|
| Stock, Jan 1.... | 4,000 | 4,550 | 32,883 | 25,000 | 11,500 | 23,000 | 9,323 |
| Production..... | 225,494 | 249,612 | 210,511 | 282,459 | 288,415 | 309,336 | 360,638 |
| Imports..... | 2,203 | 1,778 | 881 | 9,670 | 3,452 | 1,637 | 11,115 |
| Total supply. | 231,697 | 255,940 | 244,275 | 317,129 | 303,367 | 333,973 | 381,076 |
| Exports(a)..... | 4,670 | 563 | 2,640 | 2,900 | 8,457 | 18,142 | 15,334 |
| Stock, Dec. 31.. | 4,550 | 32,883 | 25,000 | 11,500 | 23,000 | 9,323 | 4,264 |
| Deliveries..... | 222,477 | 222,494 | 216,635 | 302,729 | 271,892 | 316,508 | 361,488 |

(a) Includes domestic and foreign.

The deliveries in 1911 increased by 44,500 tons over 1910 and those for 1912 increased by 45,000 tons over those for 1911. These remarkable increases in two successive years have been regarded in the trade as a good deal of a mystery. The course of the market since the beginning of 1913 has indicated clearly, however, that consumers over-bought themselves very largely during 1912. In other words, although the stock in smelters' hands was extraordinarily low at the end of 1912, the stock in consumers' yards was large. Probably the actual consumption of spelter in the United States was less than the deliveries both in 1911 and 1912. The phenomenal percentage of increase shown by the statistics is in itself indicative of such a situation, and, moreover, there is confirmatory evidence in the private statements of consumers. This is, of course, a partial explanation of the recent decline in the price for spelter.

The smelting capacity of the United States at the end of 1911 and 1912 is given in Table VI, which shows an increase of about 15,500 retorts. Certain of the smelters let some of their furnaces go permanently into disuse, thereby reducing the capacity of their works. On the other hand, certain smelters made great increases, especially the Bartlesville Zinc Co., in its works at Collinsville, Okla., the Grasselli Chemical Co., the New Jersey Zinc Co. in its Palmerton plant, and the Tulsa Fuel & Manufacturing Co., at Collinsville, Okla.

The only new works that went into operation in 1912 was the Hillsboro plant of the American Zinc, Lead & Smelting Co., which started in November with 1600 retorts. The plant of the Robert Lanyon Zinc & Acid Co., 1600 retorts, also at Hillsboro, Ill., was not completed in 1912, but is expected to be early in 1913. Including this, 10,392 retorts were in course of construction at the end of 1912, this number comprising 4560 at Depue, 1800 at Danville and 2400 at Hillsboro. It will be observed that all of the new construction is now going on in Illinois. The large additions to the works at Depue and Danville probably will be ready at an early date, inasmuch as they are being made at the works of going concerns, which always is easier than in the erection of entirely new plants. Probably there will be no further additions of consequence to the works of the gas smelters in Kansas and Oklahoma. The question of prime importance is whether additions in Illinois will be made with sufficient rapidity to offset the disappearance of smelting capacities in Kansas and Oklahoma. Anticipating the failure of its gas supply at Bartlesville, the National Zinc Co., on Jan. 1, 1913, took over the works of the United Zinc & Chemical Co., at Argentine, Kan., and Springfield, Ill., under a long lease.

VI. ZINC SMELTING CAPACITY OF THE UNITED STATES.
(Number of Retorts at End of Years.)

| Name. | Location. | 1911. | 1912. |
|---|---|---|---|
| American Zinc, Lead & Smelting Co | Hillsboro, Ill. | ..... | 1,600 |
| American Zinc, Lead & Smelting Co | Deering, Kan. | 3,840 | 3,840 |
| American Zinc, Lead & Smelting Co | Caney, Kan. | 3,648 | 3,648 |
| Bartlesville Zinc Co. | Bartlesville, Okla. | 5,184 | 5,184 |
| Bartlesville Zinc Co. | Collinsville, Okla. | 3,200 | 8,064 |
| Chanute Zinc Co. | Chanute, Kan. | 1,280 | 1,280 |
| Beer, Sondheimer & Co. | Altoona, Kan. | 3,840 | 3,300 |
| L. Vogelstein & Co. | Gas City, Kan. | (a) 2,560 | (a) 2,560 |
| L. Vogelstein & Co. | La Harpe, Kan. | 1,856 | 640 |
| Collinsville Zinc Co. | Collinsville, Ill. | (b) 1,536 | 1,536 |
| Edgar Zinc Co. | St. Louis, Mo. | 2,000 | 2,000 |
| Edgar Zinc Co. | Cherryvale, Kan. | 4,800 | 4,800 |
| Granby Mining & Smelting Co. | Neodesha, Kan. | 3,840 | 3,840 |
| Grasselli Chemical Co. | Clarksburg, W. Va. | 5,760 | } 12,672 |
| Grasselli Chemical Co. | Meadowbrook, W. Va. | 3,456 | |
| Hegeler Bros. | Danville, Ill. | 1,800 | 1,800 |
| Illinois Zinc Co. | Peru, Ill. | 4,640 | 4,640 |
| Lanyon-Starr Smelting Co. | Bartlesville, Okla. | 3,456 | 3,456 |
| Matthiesen & Hegeler | Lasalle, Ill. | 4,380 | 5,256 |
| Mineral Point Zinc Co. | Depue, Ill. | 4,520 | 4,520 |
| National Zinc Co. | Bartlesville, Okla. | 4,256 | 4,256 |
| Nevada Zinc Co. | Nevada, Mo. | (c) 648 | (b) 648 |
| New Jersey Zinc Co. | Palmerton, Penn. | 2,892 | 5,772 |
| Pittsburg Zinc Co. | Pittsburg, Kan. | 448 | 910 |
| Prime Western Spelter Co. | Gas City, Kan. | 5,384 | 4,834 |
| Sandoval Zinc Co. | Sandoval, Ill. | 896 | 896 |
| Tulsa Fuel and Manufacturing Co. | Collinsville, Okla. | 3,320 | 6,232 |
| United States Zinc Co. | Pueblo, Colo. | 1,680 | 1,920 |
| United Zinc and Chemical Co. | Springfield, Ill. | 3,680 | 3,200 |
| | | 87,800 | 103,304 |

(a) Inactive. (b) Inactive during latter part of year. (c) Not operating in 1911, but preparing for production in 1912.

VII. EXPORTS OF ZINC ORE AND ZINC OXIDE FROM THE UNITED STATES. (a)

| Year. | Ore. | | | Oxide. | | |
|---|---|---|---|---|---|---|
| | Short tons. | Value. | Value per ton. | Short tons. | Value. | Value per ton. |
| 1899.... | 28,221 | $725,944 | $25.90 | 5,343 | $366,598 | $68.61 |
| 1900.... | 42,062 | 1,134,663 | 26.98 | 5,656 | 496,380 | 87.76 |
| 1901.... | 44,146 | 1,167,684 | 26.45 | 4,561 | 393,259 | 86.22 |
| 1902.... | 55,733 | 1,449,104 | 26.00 | 5,358 | 433,722 | 80.93 |
| 1903.... | 39,411 | 987,000 | 25.04 | 7,215 | 578,215 | 80.14 |
| 1904.... | 35,911 | 905,782 | 25.22 | 8,157 | 628,494 | 77.05 |
| 1905.... | 30,946 | 848,451 | 27.41 | 11,280 | 810,203 | 71.83 |
| 1906.... | 27,720 | 733,300 | 26.45 | 15,578 | 1,149,297 | 73.78 |
| 1907.... | 20,352 | 579,490 | 28.47 | 13,256 | 1,069,924 | 80.71 |
| 1908.... | 26,108 | 877,745 | 33.60 | 12,008 | 845,070 | 70.37 |
| 1909.... | 12,456 | 412,300 | 33.10 | 14,846 | 1,026,377 | 69.14 |
| 1910.... | 19,711 | 649,425 | 32.95 | 13,166 | 943,968 | 71.69 |
| 1911.... | 18,281 | 642,884 | 44.12 | 14,618 | 1,051,311 | 71.92 |
| 1912.... | 23,349 | 823,997 | 35.30 | 17,064 | 1,247,702 | 73.12 |

(a) In addition to the exports of ore, 15,887 short tons of zinc dross (galvanizers' waste) were exported in 1906, 9593 short tons in 1907, 8405 short tons in 1908, 7069 short tons in 1909, 4728 short tons in 1910, 4246 tons in 1911, and 205 tons in 1912.

VIII. EXPORTS OF DOMESTIC SPELTER FROM THE UNITED STATES. (a)

| Year. | Plates, Sheets, Pigs and Bars. | | Wares. | Total Value. |
|---|---|---|---|---|
| | Short Tons. | Value. | Value. | |
| 1898.... | 10,499 | $1,033,959 | $138,165 | $1,724,188 |
| 1899.... | 6,755 | 742,521 | 143,232 | 1,978,295 |
| 1900.... | 22,411 | 2,217,963 | 99,288 | 2,317,251 |
| 1901.... | 3,390 | 228,906 | 82,046 | 310,952 |
| 1902.... | 3,237 | 300,557 | 114,197 | 414,754 |
| 1903.... | 1,521 | 163,379 | 71,354 | 234,733 |
| 1904.... | 10,073 | 1,094,490 | 117,957 | 1,212,447 |
| 1905.... | 5,516 | 682,254 | 159,995 | 842,249 |
| 1906.... | 4,670 | 583,526 | 204,269 | 787,795 |
| 1907.... | 563 | 75,526 | 186,283 | 261,397 |
| 1908.... | 2,640 | 250,254 | 88,485 | 338,739 |
| 1909.... | 2,566 | 263,010 | 69,751 | 332,761 |
| 1910.... | 3,990 | 426,560 | 101,336 | 527,896 |
| 1911.... | 6,872 | 810,099 | 134,518 | 944,617 |
| 1912.... | 6,634 | 864,292 | 140,027 | 1,004,319 |

(a) There is also a comparatively insignificant re-export of foreign-made spelter and zinc wares.

IX. IMPORTS OF ZINC AND ZINC OXIDE INTO THE UNITED STATES.
(In pounds.)

| Year. | Sheets, Blocks, Pigs and Old. | | Manufactures. | Total Value. | Oxide. | |
|---|---|---|---|---|---|---|
| | Amount. | Value. | | | Dry. | In Oil. |
| 1898.. | 2,742,357 | $109,624 | $13,448 | $123,072 | 3,342,235 | 27,050 |
| 1899.. | 2,985,463 | 151,956 | 14,800 | 166,756 | 3,012,709 | 41,699 |
| 1900.. | 2,013,196 | 97,772 | 36,836 | 134,608 | 2,618,808 | 38,706 |
| 1901.. | 775,881 | 30,920 | 42,643 | 73,563 | 3,199,778 | 128,198 |
| 1902.. | 1,238,091 | 46,713 | 37,191 | 83,904 | 3,271,385 | 163,081 |
| 1903.. | 728,614 | 30,900 | 18,938 | 49,838 | 3,487,042 | 166,034 |
| 1904.. | 933,474 | 44,326 | 11,918 | 56,244 | 2,585,661 | 224,244 |
| 1905.. | 1,042,081 | 51,052 | 12,390 | 63,442 | 3,436,367 | 342,944 |
| 1906.. | 4,407,481 | 253,310 | 17,385 | 270,695 | 4,191,476 | 292,538 |
| 1907.. | 3,555,890 | 210,322 | 16,282 | 226,604 | 5,311,318 | 362,418 |
| 1908.. | 1,762,627 | 85,885 | 7,474 | 93,359 | 4,635,101 | 210,166 |
| 1909.. | 19,340,029 | 826,588 | 19,176 | 845,764 | 6,119,328 | 535,024 |
| 1910.. | 6,904,389 | 289,689 | 27,475 | 317,164 | 6,133,840 | 336,257 |
| 1911.. | 3,275,340 | 170,634 | 124,983 | 295,617 | (a)5,561,016 | ..... |
| 1912.. | 22,229,831 | 1,280,426 | 293,089 | 1,573,515 | (a)5,875,057 | ..... |

(a) Both dry and in oil.

## The Spelter Market in 1912

*United States.*—It is necessary to go back to the time when American supply of spelter was chiefly derived through importations from Europe to find a period when prices on an average ruled as high as the level at which business was done during the greater part of 1912. A number of causes contributed to this result, chief of which was a remarkable increase in the consumption of spelter, particularly for galvanizing purposes. The statistics for 1911 showed the stock of spelter carried over into 1912 to be unusually low. Consumers, as a general rule, had been pursuing the policy of supplying their wants ahead to the extent of not more than 30 to 60 days. Smelters thus finding themselves sold up for the near-by months were in the market as sellers for deliveries for which there was no active inquiry. In consequence, belated buyers for early shipments could only cover their wants at a decided premium. This premium at times assumed considerable proportions, particularly when the spelter available to supply the spot demand could only be furnished by speculators, who were not slow to take advantage of the situation.

The general tendency as between early deliveries and late deliveries, as illustrated in the foregoing, governed the market for the greater part of the year. The position ultimately became so strained, due to the fact that domestic consumption had outrun the production, that prices advanced to a level which made importations of foreign spelter possible, and the arrivals of this spelter during the last quarter of the year tended to ameliorate the tense position of the market. The quantity imported up to the end of 1912 amounted to about 11,000 tons, but it is reported that actual purchases have exceeded this tonnage, so that some deliveries of spelter from Europe will fall into the new year.

At the beginning of January, 1912, prices stood at 6.10 @ 6.25 cents, St. Louis. An extraordinary demand developed, which carried the market by the middle of March to 6.50 @ 6.80 cents, St. Louis. The wide spread indicates the difference in the price between early and late shipments. The smelters benefited by the premium realized for early shipments only to the extent of the small reserves which they are wont to hold back from their current output in order to protect against unforeseen contingencies. It goes without saying that the conditions which existed, with alternating periods of amelioration and aggravation, were possible only in a market entirely bare of stocks. Reports of a sharp drop in the foreign market, for which there was no adequate explanation, and the end of which could not then be foreseen, produced an unsettling effect. Smelters, being anxious to sell against their ore receipts, tried to force the market, but fortunately for them buyers withdrew for

the deliveries which the smelters had available, and the only effect was to shake out such spelter as had been held back for nearby shipment, resulting in a decline to about 6.25 @ 6.40 cents early in April. The market, however, was very much stronger than it looked, and changed front as soon as a steadier tone made its appearance in Europe. The buyers who had been holding off pending the removal of the uncertain factors came in with a rush, and without practically any setback prices climbed up until 7 cents, St. Louis, was reached toward the end of July.

The volume which the demand assumed was surprising. New production did not develop so fast as had been expected. The conviction gained ground that the smelting capacity was likely to be diminished by troubles in the gas fields about as rapidly as it increased in the coal fields. The failure of the gas supply in the Kansas and Oklahoma fields had been hanging over the market for some time. Smelters were forced to extend their pipe-lines and to use oil in order to maintain their operations, and in consequence the smelting cost was materially increased. While in Kansas the gas supply had been more or less intermittent for some time previous, the trouble in Oklahoma confronted the market more suddenly. The Oklahoma smelters have now been forced to great expense to replenish their failing gas fields, but with the exception of one of the plants in Bartlesville succeeded in maintaining operations throughout 1912. A realization of this situation made sellers more conservative, particularly in the matter of disposing of their product at a heavy discount for future delivery.

After a short interim in August, when prices reacted slightly, due largely to realization of some speculative holdings, the market again resumed its advance, until the high point of the year was reached in September, when quotations ruled at 7.35 @ 7.45 cents, St. Louis. It became evident then that the output, although going on at a very heavy rate, was not adequate to take care of the consumption, which latter was greatly accelerated through the remarkable prosperity in the iron and steel trade, as well as the resumption of activity in all of the brass mills of the country at a rate which had not prevailed since 1906. Fortunately, the position in Europe made it possible to import spelter, as otherwise the market would have passed entirely beyond control and reason. Due to these imports, the premium for early shipments gradually diminished and the market assumed a more normal aspect. A gradual decline set in and at the close of 1912 prices were steady at 7.05 @ 7.10 cents, St. Louis.

*London.*—The market in January opened at £26 15s. per ton for ordinary brands and so remained till Jan. 24. Consuming industries were fully employed, but requirements were covered, and producers

having sold well, were not pressing sales. This inaction prompted some dealers to shade prices, £26 being ultimatly accepted for delivery extending into April, earlier delivery commanding higher prices. Closing quotations were £26 for ordinary brands, and £27 5s. for Silesian specials.

A fractional decline in February was followed by a rapid recovery due to shortage of supplies, prices ranging from £26 2s. 6d. to £26 15s. according to time of delivery, and with fair demand from the home trade. A threatened strike of coal miners then made buyers cautious, but continental demand kept the market steady, closing at £26 5s. @ £26 10s. for ordinaries, £27 7s. 6d. for specials.

In March the coal strike greatly curtailed business throughout the month, and prices weakened under pressure from sellers outside the Producers' Syndicate. The latter then made a drastic cut of £2 per ton, whereupon consumers bought largely. A subsequent advance of 5s. was also paid, and all offers thereat were absorbed, delivery extending into May. The close was at £25 5s. @ £25 10s. for ordinaries, £26 5s. for specials.

The coal strike ended, and with great expansion in the iron trade, spelter was in constant request in April, and second-hand supplies were quickly cleared. The Producers' Syndicate made successive moderate advances in prices, which were readily paid. Closing prices were £25 15s. @ £25 17s. 6d. for ordinaries, and £26 10s. for specials.

In May consumption continued everywhere active, and business in fair volume. The London quotation was depressed by sale of speculative holdings, down to £25 12s. 6d. and so closed, with £26 10s. for specials. June prices remained practically unchanged in London, all incoming supplies being quickly absorbed for consumption, while continental prices advanced. Ordinary brands closed at £25 12s. 6d. @ £25 15s.; with £26 10s. for specials.

In contrast to other metals, spelter experienced a quiet market throughout July, consumers having already covered their requirements, and producers having sufficiently sold their output. American consumption expanded largely, fully absorbing the native production and threatening to invade European supplies. The London quotation was somewhat nominal, closing at £25 12s. 6d. @ £26 for ordinaries; £26 10s. for specials.

Official statistics testified to the large expansion of the galvanizing industry, and trade in sheet zinc was increasing rapidly in August. Second-hand spelter was soon bought up, and values thereafter advanced with business extending in some cases up to the end of the year. Ordinary brands closed at £26 10s., with £27 5s. for specials.

Industrial activity in both hemispheres resulted in brisk September business and for very extended delivery, and producers were constrained to advance their prices twice. The London quotation advanced proportionately, closing at £27 10s. for ordinary brands; £28 5s. for specials. In October hostilities in southeastern Europe, and consequent depression in the Stock Markets, disturbed trade generally; but spelter remained unaffected by politics or finance, so evenly balanced were supply and demand. The closing prices of September ruled throughout.

In November dealers made gradual concessions which, later in the month, reduced the London quotation far below that for which producers were holding. The event of the month was on Nov. 26, when the Producers' Syndicate made a drastic cut of £1 15s. in the price. Thereat consumers were alert to cover their requirements, and a large business resulted, quickly followed by an advance of 5s. per ton, whereat also large business was done. Ordinary brands closed at £26 2s. 6d.; with £26 17s. 6d. paid for specials.

December saw rather a quiet but steady market. Consumption continued good, and the possibility of exports to America was also considered. In the later days of the month some weakness developed, and closing quotations were £26 7s. 6d. for ordinary brands; £27 for specials.

AVERAGE MONTHLY PRICE OF SPELTER PER POUND IN ST. LOUIS.

| Year. | Jan. | Feb. | Mar. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. |
| 1904.... | 4.673 | 4.717 | 4.841 | 5.038 | 4.853 | 4.596 | 4.723 | 4.716 | 4.896 | 5.033 | 5.363 | 5.720 | 4.931 |
| 1905.... | 6.032 | 5.980 | 5.917 | 5.667 | 5.284 | 5.040 | 5.247 | 5.556 | 5.737 | 5.934 | 5.984 | 6.374 | 5.730 |
| 1906.... | 6.337 | 5.924 | 6.056 | 5.931 | 5.846 | 5.948 | 5.856 | 5.878 | 6.056 | 6.070 | 6.225 | 6.443 | 6.048 |
| 1907.... | 6.582 | 6.664 | 6.687 | 6.535 | 6.291 | 6.269 | 5.922 | 5.551 | 5.086 | 5.280 | 4.775 | 4.104 | 5.812 |
| 1908.... | 4.363 | 4.638 | 4.527 | 4.495 | 4.458 | 4.393 | 4.338 | 4.556 | 4.619 | 4.651 | 4.909 | 4.987 | 4.578 |
| 1909.... | 4.991 | 4.739 | 4.607 | 4.815 | 4.974 | 5.252 | 5.252 | 5.579 | 5.646 | 6.043 | 6.231 | 6.099 | 5.352 |
| 1910(*a*) | 5.951 | 5.419 | 5.487 | 5.289 | 5.041 | 4.978 | 5.002 | 5.129 | 5.364 | 5.478 | 5.826 | 5.474 | 5.370 |
| 1911(*a*) | 5.302 | 5.368 | 5.413 | 5.249 | 5.198 | 5.370 | 5.545 | 5.803 | 5.719 | 5 951 | 6.223 | 6.151 | 5.608 |
| 1912(*a*) | 6.292 | 6.349 | 6.476 | 6.483 | 6.529 | 6.727 | 6.966 | 6.878 | 7.313 | 7.276 | 7.221 | 7.081 | 6.799 |

(*a*) From *Eng. and Min. Journ.*

AVERAGE MONTHLY PRICE OF SPELTER PER POUND IN NEW YORK.

| Year. | Jan. | Feb. | Mar. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. |
| 1901.... | 4.13 | 4.01 | 3.91 | 3.98 | 4.04 | 3.99 | 3.95 | 3.99 | 4.08 | 4.23 | 4.29 | 4.31 | 4.07 |
| 1902.... | 4.27 | 4.15 | 4.28 | 4.37 | 4.47 | 4.96 | 5.27 | 5.44 | 5.49 | 5.38 | 5.18 | 4.78 | 4.84 |
| 1903.... | 4.87 | 5.04 | 5.35 | 5.55 | 5.63 | 5.70 | 5.66 | 5.73 | 5.69 | 5.51 | 5.39 | 4.73 | 5.40 |
| 1904.... | 4.863 | 4.916 | 5.057 | 5.219 | 5.031 | 4.760 | 4.873 | 4.866 | 5.046 | 5.181 | 5.513 | 5.872 | 5.100 |
| 1905.... | 6.190 | 6.139 | 6.067 | 5.817 | 5.434 | 5.190 | 5.396 | 5.706 | 5.887 | 6.087 | 6.145 | 6.522 | 5.882 |
| 1906.... | 6.487 | 6.075 | 6.209 | 6.078 | 5.997 | 6.096 | 6.006 | 6.027 | 6.216 | 6.222 | 6.375 | 6.593 | 6.198 |
| 1907.... | 6.732 | 6.814 | 6.837 | 6.685 | 6.441 | 6.419 | 6.072 | 5.701 | 5.236 | 5.430 | 4.925 | 4.254 | 5.962 |
| 1908.... | 4.518 | 4.788 | 4.665 | 4.645 | 4.608 | 4.543 | 4.485 | 4.702 | 4.769 | 4.801 | 5.059 | 5.137 | 4.726 |
| 1909.... | 5.141 | 4.889 | 4.757 | 4.965 | 5.124 | 5.402 | 5.402 | 5.729 | 5.796 | 6.199 | 6.381 | 6.249 | 5.503 |
| 1910(*a*) | 6.101 | 5.569 | 5.637 | 5.439 | 5.191 | 5.128 | 5.152 | 5.279 | 5.514 | 5.628 | 5.976 | 5.624 | 5.520 |
| 1911(*a*) | 5.452 | 5.518 | 5 563 | 5.399 | 5.348 | 5.520 | 5.695 | 5.953 | 5.869 | 6.102 | 6.380 | 6.301 | 5.758 |
| 1912(*a*) | 6.442 | 6.499 | 6.626 | 6.633 | 6.679 | 6.877 | 7.116 | 7.028 | 7.454 | 7.426 | 7.371 | 7.162 | 6.943 |

(*a*) From *Eng. and Min. Journ.*

AVERAGE MONTHLY PRICE OF SPELTER IN LONDON.
(Pounds sterling per ton of 2240 lb. of good ordinary brands.)

| Year. | Jan. | Feb. | Mar. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | £. | £. | £. | £. | £. | £. | £. | £. | £. | £. | £. | £. | £. |
| 1906.... | 28.225 | 25.844 | 24.563 | 25.781 | 27.000 | 27.728 | 26.800 | 26.938 | 27.563 | 28.075 | 27.787 | 27.938 | 27.020 |
| 1907.... | 27.125 | 25.938 | 26.094 | 25.900 | 25.562 | 25.469 | 23.850 | 21.969 | 21.050 | 21.781 | 21.438 | 20.075 | 23.771 |
| 1908.... | 20.563 | 20.875 | 21.075 | 21.344 | 19.906 | 19.000 | 19.031 | 19.350 | 19.563 | 19.750 | 20.875 | 20.625 | 20.163 |
| 1909.... | 21.425 | 21.563 | 21.438 | 21.531 | 21.975 | 22.000 | 21.969 | 22.125 | 22.906 | 23.200 | 23.188 | 23.094 | 22.185 |
| 1910(a). | 23.350 | 23.188 | 23.031 | 22.469 | 22.100 | 22.094 | 22.406 | 22.800 | 23.165 | 23.900 | 24.083 | 24.019 | 23.050 |
| 1911(a). | 23.887 | 23.276 | 23.016 | 23.743 | 24.375 | 24.612 | 25.006 | 26.801 | 27.750 | 27.256 | 26.795 | 26.849 | 25.281 |
| 1912(a). | 26.642 | 26.661 | 26.048 | 25.644 | 25.790 | 25.763 | 26.174 | 26.443 | 27.048 | 27.543 | 26.804 | 26.494 | 26.421 |

(a) From *Eng. and Min. Journ.*

## How Spelter is Sold[1]

The American zinc industry has escaped any general consolidation and there has not developed in it any single concern of sufficient power even to attempt to regulate the price. This may be ascribed primarily to the nature of the occurrence of the ore deposits which are worked in a multitude of mines whereof a general control would be a hopeless undertaking. Given therefore an open supply of ore and a metallurgical process for its reduction that does not so strenuously demand mixtures as does the process of lead smelting, the metallurgical side of the industry is also bound to remain open. There are other conditions favoring the maintenance of that condition, but what I have stated will suffice as a broad generalization. There have, indeed, been numerous consolidations of groups of works during the last 20 years, but these have been simply promotive of efficiency, not restrictive of competition. In many cases the vendors of works have promptly built new works with the money received for their old ones, and have successfully continued in the smelting business. However, there has been during the last 15 years a natural segregation of interest, which has been merely a manifestation of the modern tendency to substitute strong industrial units for small and weak ones, and this of course has had an effect upon market conditions, especially in the conversion of the brokerage houses into producers.

*Elimination of the Middlemen.*—Twenty years ago the production of spelter was largely made by small concerns, mostly of small capital and frequently on the ragged edge of insolvency. Their policy was commonly to combine smelting and speculation and their purchases of ores and sales of spelter were largely governed by their forecasts of the market. When pinched by some unforeseen turn and caught with a stock of spelter on hand their lack of resources compelled them to unload at a sacrifice upon some one of the metal houses able to carry the stock and distribute

[1] *Eng. and Min. Journ.*, Oct. 26, 1912.

it to consumers later on. These metal houses often were called upon to make advances to smelters and through the combination of their banking and merchandizing facilities became great factors in the business.

As the smelting industry became concentrated in fewer and stronger hands the necessity for such middlemen disappeared, and the latter being desirous of maintaining their well organized system of merchandising, their only recourse was to go into the smelting business themselves, whereby their purview was extended beyond the production of zinc as spelter and to the zinc-ore market, but none has actually entered upon the production of ore.

*The Smelting Interests.*—A list of the American zinc smelters is given on a preceding page of this article. It will be observed that there are five concerns each possessing upward of 6000 retorts. Of these the Edgar Zinc Co. is controlled by the United States Steel Corporation and supplies it with spelter to a large extent. There are seven concerns with less than 2000 retorts each. There are six concerns with from 2000 to 6000 retorts. Of these, the Matthiessen & Hegeler Zinc Co. and the Illinois Zinc Co. consume the major part of their product in the manufacture of sheet zinc. The New Jersey Zinc Co., the American Zinc Lead & Smelting Co. and the Granby Mining & Smelting Co. are the only ones of these smelters who have any mining interests worth mentioning.

*Kinds of Spelter.*—At the annual meeting of the American Society for Testing Materials in June, 1911, Prof. William Campbell, of Columbia University, chairman of the committee on "Non-ferrous Metals and Alloys" reported a classification of the kinds of spelter, the figures representing the maximum percentages of impurities allowable. This classification is rational and corresponds substantially to the understanding among American zinc smelters. The trade recognizes different grades of some of these kinds of spelter. Thus, "Horsehead" and "Bertha" spelters are considered to be superior to any other brands of high-grade spelter and realize the highest premiums. "Glendale Refined" is, so far as I am aware, the only kind of intermediate spelter. This is made out of especially selected ore. Prime Western spelter corresponds to the "Good Ordinary Brands" of the European market. The bulk of the American spelter product is of this class. There is considerable

KINDS OF SPELTER.

| Kind. | Pb. | Fe. | Cd. | Total not over |
|---|---|---|---|---|
| A. High grade[1] | 0.07 | 0.03 | 0.05 | 0.10 |
| B. Intermediate[1] | 0.20 | 0.03 | 0.05 | 0.50 |
| C. Brass special[1] | 0.75 | 0.04 | 0.75 | 1.20 |
| D. Prime Western | 1.50 | 0.08 | ..... | ..... |

[1] To be free from aluminum.

variation in the quality of the several brands. Most of the Prime Western spelter is now made out of ore from the far West. There are some smelters who continue to use mainly a good grade of Joplin ore and produce a spelter standing between Prime Western and Brass Special and realizing therefor a small premium.

The price commanded by the high-grade spelter is so much above that realized for Prime Western that to all intents and purposes it is a different metal. The premium runs anywhere from 2 to 4 cents per pound.[1] The premium for intermediate spelter is usually from 1 to 2 cents per pound. Brass Special fetches a premium of from 5 to 25 cents per 100 lb. The high-grade and intermediate spelters are made by few concerns, which are able to command their own terms. Brass Special is made by many concerns and the supply of it is relatively abundant. In speaking commonly of the price of spelter, the price for Prime Western is meant.

*Marketing.*—In the main the producers market their own spelter, *i.e.*, they sell it directly to consumers. So far as I am aware there is none sold regularly through the metal-selling agencies on commission,[2] but these agencies not infrequently buy outright from some of the weaker smelters still remaining, who find among them an ever-present market at a price. It goes without saying that with so many producers of spelter the competition among them to dispose of their product is keen. In this market, in fact, the common condition is reversed, the concentration being on the consuming side, not on the producing. The United States Steel Corporation alone takes upward of 30 per cent. of the entire make of prime western spelter, and the activity in the spelter market is likely to depend upon whether that company is buying or not buying.

*General Conditions.*—The conditions governing the marketing of spelter are in the main the same as in the marketing of copper, described on an earlier page of this volume. The so-called "spot" business is essentially of a retail character, the main business in the metal being on contracts, which are made for a longer or shorter period ahead according to notions of what the future is going to develop. The stock of spelter in the hands of the smelters is always relatively small. Anything like 25,000 tons is considered large, but in fact that is only about the production of one month and includes all kinds of the metal. At some times there may be a practically complete disappearance of stocks, and

[1] The supply of high-grade spelter could no doubt be greatly increased if there were need for it, and prospective competitors in this market would find it hazardous to reckon upon the full premium now realized.

[2] I exclude from this statement the sales by L. Vogelstein & Co., for the American Zinc, Lead & Smelting Co., and of Beer, Sondheimer & Co., for the National Zinc Co., where the agents are interested in the respective producing companies.

buyers who must have some metal for immediate delivery are likely to be required to pay stiff premiums, but such are in no way representative of the broad commodity market because but relatively little business is done under those conditions, the bulk being in contracts anticipating requirements.

When contracts are made for a long time ahead there may be a differential in the price, plus or minus, according to the preponderance of views respecting the future. Most of the smelters are governed by their position as to ore supply. Those who take in ore under contract, on a sliding scale, desire normally immediately to sell spelter against it. The trend toward a rising market must be very well defined and certain to cause them to adopt a policy of reserve in their selling. The smelter who buys his ore as needed or as offered will always be governed in his attitude toward the spelter market by the quantity and cost of his stock.

*St. Louis the Basing Point.*—It has become the custom in the American spelter market to adopt the price at St. Louis as the basis for contracts and business generally. The spelter may not actually be sold there and it may not even pass through there on its way to the buyers. Some spelter is actually sold in St. Louis, but a very large quantity is sold in New York on St. Louis basis. The price at New York, if ever it be necessary to refer to it, is simply the St. Louis price plus 15 cents per 100 lb., which is the freight rate from St. Louis to New York.

St. Louis is a natural basing point, because the major part of the consumption of spelter in the United States occurs at places between it and New York. Upon the rare occasions when European spelter is imported through New York, as in September, 1912, New York may become an independent basis point and there may be a variation from the normal freight differential, but this is only temporary. Importations of foreign spelter will begin, of course, when consumers in the immediate vicinity of New York, or in Connecticut, can be supplied more cheaply than from the western smelting points, while the latter may still retain the interior market.

*Speculation in Spelter.*—There is more speculation in spelter than there is in copper. The fluctuations in the price are rapid and often violent, the sellers of spelter for distribution are numerous, no single interest is predominant, all of which conditions contribute to the absence of aversion to speculative participation in this market such as exists in the copper market. There are many smelters who will sell spelter to anybody who wants to buy it, hold the spelter and issue certificates representing it. These certificates may pass from hand to hand and be redeemed after five or six endorsements have been made on them. They

correspond, of course, to any warehouse receipt. It is, however, only at times that there are general transactions of this kind.

Similarly as to transactions on the New York Metal Exchange. They are never of any great volume or significance. Long periods may elapse without there being any at all. Then several hundred tons may be sold in a day. These reflect speculative business. Consumers do not buy through the Metal Exchange. Most of the smelters do not try to sell through it or indeed pay any attention to it. Some smelters are represented upon it and may buy up what is offered there, especially if it be desired to clean up the market of speculative spelter. In the same way there are transactions from hand to hand in St. Louis, although there is no organized exchange there, the business being of the nature of that of a curb market. The entire volume of the business of this kind, both in New York and St. Louis, is only a few hundred tons per month and is insignificant in comparison with the marketing of the bulk of the spelter product, which is done directly between producers and consumers. Almost without exception the smelters give preference to orders from consumers over orders from dealers, and frequently give the former as much as 5 cents per 100 lb. advantage in price, and even more.

The real spelter market being established by private transactions between producers and consumers the information reflecting the market can come only from them. Among such transactions there are often considerable differences, the means of exchanging information in the spelter market being distinctly inferior to those of the copper market. Some consumers do considerable "shopping," others do not. Some who do so ordinarily may upon certain occasions make a negotiation with some one smelter without letting anybody else know that he is in the market. The direct market, if I may use that term, is often quite different from the speculative, or semi-speculative, street market. The quotations made on the New York Metal Exchange do not ordinarily command any serious attention anywhere. Before accepting any quotations made there it is necessary to know whether anybody trading in spelter was present at the call and whether the price was the result of a genuine transaction. If nobody who wants to buy or sell spelter be present at the call it is easy of course to bid up, or offer down, the price 1/8 to 1/4 cent above or below the real market.

The conditions above recited explain the contradictory reports about the spelter market that frequently are in circulation. In cases of discrepancy the high figures are generally to be rejected on the probability that they represent merely prices that are squeezed on a small order required under special conditions or in speculative business that is small in volume anyway.

*Foreign Relations.*—The tariff on spelter causes the American market to be independent of the European market during most of the time. Formerly, American smelters used to dump a good deal of spelter upon the European market at certain times, but during recent years no such opportunity has arisen. On the other hand, we have lately witnessed circumstances in which we were upon the verge of importing European spelter, duty paid, and have actually made such importations.[1] At these times the European market was a restraining influence to a further rise in our own. Similarly, upon other occasions, the possibility of exporting spelter has checked a decline in our market. Except for these conditions the European market and American market may display wide disparity and doubtless will continue to do so so long as our producers are protected by the tariff on zinc ore and spelter.

## Zinc Ore Mining in the United States

*Arizona.*—The production of zinc ores in 1912 showed a remarkable increase; the total output amounted to the equivalent of about 4200 tons of metal. One of the most important producers was the Galconda mine at Union Basin, in Mohave County. This mine shipped, during one of the autumn months, about 35,000 tons of ore and concentrate. The American Zinc, Lead & Smelting Co. bonded and began development of a promising deposit of zinc ore in the Dragoon district.

*Arkansas.*—In northern Arkansas, according to the U. S. Geol. Surv., the output of zinc concentrates in 1912 increased 40 per cent. over that of the previous year. The principal features of the year were the development of zinc carbonate mining in the vicinity of Zinc and the construction of a 200-ton mill at the old Morning Star mine, long a producer of carbonate ores. Only about one-fifth of the 1419 tons of zinc concentrates classed as sphalerite was of high grade, the bulk of this class being a mixed ore carrying about 75 per cent. of sphalerite. The production of zinc carbonate and zinc silicate concentrates increased from 183 tons in 1911 to 462 tons in 1912. Mines in Marion County, of which the Frisco was the principal shipper, produced over two-thirds of the ore of this class from Arkansas, and nearly all the rest of the production was derived from the Bennett and Keyes mines in Newton County. The total recoverable zinc content of the concentrates sold was 748 tons, valued at $105,222.

*California.*—The production of zinc made a large increase in 1912, being about double that of the previous year. There are but two pro-

[1] We are, of course, importing foreign zinc ore all the time and smelting it in bond, the product being exported or entered for consumption according to the market conditions of the moment. The duty on imported spelter is 1¼ cents per pound; on zinc in ore, 1 cent per pound.

ducers, the Cerro Gordo mine, in Inyo County, and the Uncompagre, in San Bernardino County. The Cerro Gordo mine, formerly operated as a lead mine, shipped zinc carbonate ore at the rate of 900 tons monthly during the greater part of the year.

*Colorado* (By George E. Collins).—The high prices ruling for zinc ores in 1912 permitted the shipment of larger tonnages, especially from Leadville. Elsewhere the high price was not taken advantage of fully, mainly because of the small size of most of the individual deposits, which do not warrant the provision of the elaborate and expensive dressing and separating plants necessary to make marketable products from the complex sulphide ores characteristic of large areas in Colorado.

The shipments of zinc-carbonate ore from Leadville continued, and the favorable market conditions rendered profitable the mining of a grade of ore as low as 25 per cent. or even 20 per cent. This was really the salvation of the district, which otherwise, since the closing of the downtown mines in the winter of 1907–08, would have been decadent. The Wolftone and Maid of Erin maintained a large production, while the Iron Silver had also an active and successful year. The mines tributary to the Yak Tunnel also contributed largely to the output.

Apart from Leadville, the state is capable of making a large aggregate production, of zinc especially, but there is no single district which can be compared with Leadville either in present or prospective output. In the other districts, the Smuggler at Aspen, the Amethyst vein at Creede, and the Tomboy and Sunnyside in the San Juan district, are all prominent producers of lead or zinc, usually both together. In the minor districts, the Wellington at Breckenbridge and Iron Mask at Red Cliff produced largely this year, and the Mary Murphy at St. Elmo will contribute to the production of 1913.

Some of these mines use the roasting and magnetic treatment for the separation of pyrite from blende. This is the case with the Wellington and Iron Mask. The Sunnyside and Mary Murphy, on the other hand, employ the electrostatic method of separation; and a custom electrostatic plant recently commenced work at Ouray. Which method is the more advantageous seems to depend on small physical differences in the ore, on the degree to which the blende is of the rosin or nonferriferous variety, and on the proportion of chalcopyrite, which is rendered less magnetic than pyrite by roasting, and is therefore less perfectly separated magnetically from the blende. The costs of the two methods are probably about the same, the expense of the roast for the magnetic process being offset by the high royalties charged by the owners of the electrostatic patents. In some cases, as for instance, the Tomboy and Smuggler-Union at Telluride, no ultimate separation is attempted,

dependence being placed entirely on wet-dressing methods. Experiments were made with various modifications of the flotation processes, but as yet none of them has been adopted in practice.

In view of the widely spread zinc resources of the state, and the usual small extent of the individual mine, it is probable that central separating plants will ultimately be established by the zinc-smelting interests, purchasing middlings and concentrates from wet-dressing mills of the usual type. In this way a comparatively inexpensive dressing plant at the mine will suffice, and freight charges are in any case the same before and after separation. Some progress was made in this direction by the Western Chemical Co. in Denver.

Late in 1912 it was reported that the zinc smelters of Kansas and Oklahoma had agreed to accept calamine ore, containing only 18 per cent. zinc, from Leadville, Colo. That the zinc smelters employing the Belgian process should be willing to take ore so low in zinc is a remarkable change in metallurgical practice. Ore of that grade has been smelted in Silesia by the Silesian process from time immemorial, but it is not many years ago that it was considered that the smelters employing the Belgian process had to have ore averaging about 40 per cent. zinc at least. For a long time, however, American smelters have been accepting Leadville calamine containing about 25 per cent. zinc. Their willingness to take that, and now a still lower grade, is, of course, attributable to the situation in Kansas and Oklahoma with respect to fuel supply. The natural gas upon which these smelters are dependent has for a long time been becoming more and more costly, while also the type of roasting furnace commonly used by them is extremely wasteful of fuel. While during 1912 Western blende fetched a relatively low price, leaving a large margin to the smelters, calamine commanded a relatively high price, the explanation being that the blende has to be roasted while calamine does not.

*Idaho* (By Robert N. Bell).—The production of zinc ore in Idaho in 1912 came mostly from two properties, both of which are situated in the Cœur d'Alene district. The Success mine was the principal producer, with an output of ore containing 11,000,000 lb. of zinc. The Morning mine, which operates a MacQuisten-tube plant treating zinc-bearing slimes, made an output of 45 per cent. concentrates containing an aggregate amount of 3,197,000 lb. of zinc. The Success mine yields ore containing about equal percentages of iron and zinc sulphides, with an appreciable amount of lead. It produced about a carload of 42 per cent. zinc concentrates per day, and a carload of 50 per cent. lead concentrates per week, by ordinary table methods.

Zinc-lead ores are prevalent both at the extreme north and south

ends of the Cœur d'Alene, and a number of well-developed properties are preparing to enter the market in 1913. The Surprise mine and the Monarch mine in 1912 each shipped 10 cars of ore containing 45 per cent. zinc.

New railroad construction to Camas Prairie, near the west end of the Wood River district, in Blaine County, reduced the former wagon haul from Smoky Creek mines half, and will encourage development. This region contains some encouraging showings of zinc-lead ore, which have been dormant for a number of years. The ores in this district carry comparatively high silver and some gold.

*Illinois.*—The output of sphalerite concentrates in 1912, according to the U. S. Geol. Surv., was 13,464 short tons, containing 4065 tons of zinc. The entire output came from the Galena district, in northwestern Illinois. The average zinc contents of the concentrates decreased from 45.3 per cent. in 1911 to 35.4 per cent. in 1912, but their average selling-price, $27.30, was only $2 per ton less than in 1911. The Unity and Vinegar Hill mines of the Vinegar Hill Zinc Co. were much the largest producers of zinc concentrates. The Northwestern Zinc Co. operated more extensively than in 1911 and made a good output, which contributed materially to the increased output from Illinois.

*Kansas.*—According to the U. S. Geol. Survey, a mine output of 774,000 tons of ore in 1912 yielded 21,258 tons of sphalerite and 125 tons of carbonate and silicate concentrates. The actual shipments of concentrates for the year will be found in the table under Joplin district, Missouri, on a following page. The zinc contents of the concentrates was about 10,633 tons.

Many of the mines in the Badger-Peacock district were inactive in 1912, and the production was small compared with that of other recent years. The Lawton district doubled its 1911 output. The yield of sphalerite concentrates in the Galena district increased by 1,394 tons in 1912 and the value was much greater because the average price paid was about $11 a ton more than in 1911.

*Kentucky.*—According to the U. S. Geol. Surv., the amount of zinc concentrates sold in 1912 comprised 493 tons of sphalerite of good grade and 750 tons of carbonate averaging 35.6 per cent. zinc. The combined value of the concentrates was $41,391. The estimated recoverable spelter content was 491 tons.

The Eclipse Mining Co. operated the Commodore mine, in the Marion district, and succeeded in successfully milling ore derived from the 185-foot level. The mill is of small capacity and the ore difficult to treat. The average recovery of concentrates from ore was approximately 10 per cent. and the average zinc content of the concentrates was in-

creased from 54.4 per cent. in early operations to over 59 per cent. All the sphalerite concentrates shipped from Kentucky in 1912 were derived from the Commodore mine.

The largest shippers of zinc carbonate concentrates were the Langenbach Mining Co., operating the Mann mine, near Lola, and the Sanders Ore Separating Co., operating on land of the Marion Mineral Co.

*Missouri, Joplin District* (By Jesse S. Zook).—Shipments of zinc sulphide and silicate ores in 1912 marked an increase of more than 35,000 tons over 1911 and 8000 tons over any preceding year. Starting with an average output in January of 3840 tons, the tremendous growth of the zinc industry brought the year to a close with an output around 7000 tons per week. The firm demand that kept zinc prices on a high level created this situation and caused the disbursement of $5,000,000 more dividends than in 1911. This record seems sufficient proof that the Joplin district has ore reserves and can increase its production when prices insure a profit. As the deepest operating level is less than 300 ft. below surface, and as drill records show ore occurring at lower levels, it is evident that only the upper levels have been developed.

At the beginning of the year the average price of all grades of zinc ore—sulphide and silicate—was $42.16. At the end of June the average had advanced to $53.90, and at the close of September to $60.40, from which point there was a decline to an average of $55 in December, the year's average being $12 per ton above that of 1911.

Missouri yielded an increase of 34,540 tons of sulphide and 410 tons of silicate. Kansas increased its sulphide output by 1830 tons, but its silicate diminished by 15 tons. Oklahoma's output increased by 400 tons of sulphide, but decreased 9 tons of silicate.

In Jasper County, all points except Sarcoxie reported an increased tonnage of sulphide ore, with an increase of silicate from Sarcoxie and Alba-Neck and a decrease from all other points—a net increase of 33,239 tons of sulphide and a decrease of 1334 tons of silicate for the county. In Newton County, Granby, Wentworth and Spurgeon yielded increased silicate, and Wentworth and Jackson increased sulphide production, a net increase of 1298 tons sulphide and 1830 tons silicate for the county.

Purchasing ore on a contract basis was very satisfactory to the purchasers in 1912, but decidedly less so to the sellers, and it has grown in disfavor. The feature that caused the most dissatisfaction was the bartering of the contract ore on the open market by the purchasers when the margin between the contracts and the open market was $6 to $8 per ton in favor of the smelters, thus affording a club to control the open-market level of prices.

A large portion of the increased tonnage of the year was produced

by improved milling practice, and by the installation of additional jigs and slime tables, which raised the percentage of saving. Remodeling and increasing capacity was thus a more potent factor than the erection of new mills. About 20 completely new concentrating mills were erected, about half of which are producing successfully. At least two of them were erected over phenomenal deposits of sulphide ore, milling 150 tons of concentrate from 1500 tons of crude ore per week, a 10 per cent. product.

ZINC- AND LEAD-ORE PRODUCTION OF THE JOPLIN DISTRICT—1912.
(In pounds.)

| District. | Zinc Sulphide. | Zinc Silicate. | Lead Ore. | Combined Value. |
|---|---|---|---|---|
| Webb City, Carterville | 225,663,680 | ..... | 51,798,080 | $7,571,998 |
| Joplin | 119,217,470 | ..... | 13,365,630 | 3,668,759 |
| Duenweg | 36,086,130 | 1,213,080 | 3,162,930 | 1,084,690 |
| Alba-Neck | 35,946,350 | 174,090 | 1,243,280 | 1,063,284 |
| Oronogo | 22,120,310 | ..... | 3,413,520 | 609,194 |
| Carl Junction | 15,339,160 | ..... | 122,580 | 434,682 |
| Cave Springs | 13,462,270 | ..... | 778,980 | 384,112 |
| Carthage | 6,998,290 | 36,480 | ..... | 182,887 |
| Sarcoxie | 1,420,360 | 384,600 | ..... | 44,883 |
| Jasper County | 476,254,020 | 1,808,250 | 73,885,000 | $15,044,489 |
| Granby | 6,793,160 | 19,923,840 | 759,360 | $492,165 |
| Spurgeon | 5,217,150 | 11,485,360 | 2,155,280 | 375,210 |
| Jackson | 12,937,160 | ..... | 823,510 | 362,810 |
| Wentworth | 3,389,860 | 425,460 | ..... | 95,148 |
| Saginaw | ..... | 88,890 | 11,610 | 1,675 |
| Newton County | 28,337,330 | 31,923,550 | 3,749,760 | $1,327,008 |
| Aurora | 2,531,310 | 2,827,860 | 82,310 | $109,166 |
| Stott City | 817,340 | ..... | ..... | 19,726 |
| Lawrence County | 3,348,650 | 2,827,860 | 82,310 | $128,892 |
| Green County | 3,675,270 | ..... | 507,410 | $117,765 |
| Kansas: | | | | |
| Galena | 37,290,340 | 119,770 | 6,068,130 | $1,183,644 |
| Lawton | 3,863,870 | ..... | 193,840 | 106,772 |
| Badger | 419,940 | ..... | 17,640 | 10,387 |
| Cherokee County | 41,574,150 | 119,770 | 6,279,610 | $1,300,803 |
| Oklahoma: | | | | |
| Miami | 19,822,930 | ..... | 9,082,930 | $723,641 |
| Quapaw | 2,437,640 | ..... | 2,020 | 59,488 |
| Ottawa County | 22,260,570 | ..... | 9,084,950 | $783,129 |
| Murray County | 33,180 | ..... | ..... | 830 |
| Missouri | 511,615,270 | 36,559,660 | 78,224,480 | $16,618,154 |
| Kansas | 41,574,150 | 119,770 | 6,297,610 | 1,300,803 |
| Oklahoma | 22,293,750 | ..... | 9,084,950 | 784,059 |
| Joplin Total | 575,483,170 | 36,679,430 | 93,589,040 | $18,703,016 |
| Total 1911 | 502,542,050 | 36,113,710 | 91,185,340 | 13,431,367 |
| 1912 Increase | 72,941,120 | 565,720 | 2,403,700 | $5,271,649 |

The production of lead ore showed a slight increase in Missouri and Oklahoma and a slight decrease in Kansas, a net district gain of 1430 tons. The average price for the year was within a few cents of the average of 1911. Within the year, the Webb City smeltery was sold, ostensibly to the American Metal Co., and a harmonious purchasing

alliance was made with the Hammer Bros. at Galena, Kan., and the Picher Lead Co. in Joplin, each becoming a subsidiary of one holding company. The Granby Mining & Smelting Co. lost its smeltery at Granby by fire, and no plans for reconstruction have been approved. The large stock of lead ore this company had on hand was sold to the St. Louis Smelting & Refining Company.

SHIPMENTS OF ORE FROM THE JOPLIN DISTRICT
(In tons of 2000 lb.)

| Year. | Zinc Ore. | Lead Ore. | Year. | Zinc Ore. | Lead Ore. |
|---|---|---|---|---|---|
| 1895 | 144,487 | 31,294 | 1904 | 267,240 | 34,362 |
| 1896 | 155,333 | 27,721 | 1905 | 252,435 | 31,679 |
| 1897 | 177,976 | 30,105 | 1906 | 278,930 | 39,189 |
| 1898 | 234,455 | 26,687 | 1907 | 286,538 | 42,065 |
| 1899 | 255,088 | 23,888 | 1908 | 258,628 | 38,532 |
| 1900 | 248,446 | 29,132 | 1909 | 296,453 | 43,659 |
| 1901 | 258,306 | 35,177 | 1910 | 294,408 | 43,707 |
| 1902 | 262,545 | 31,625 | 1911 | 269,004 | 45,593 |
| 1903 | 234,773 | 28,656 | 1912 | 306,082 | 46,794 |

AVERAGE MONTHLY PRICE OF ZINC BLENDE ORE AT JOPLIN, MO. (a)
(Dollars per 2000 lb.)

| Year. | Jan. | Feb. | Mar. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1903 | 31.50 | 32.50 | 35.75 | 37.75 | 36.60 | 36.50 | 36.00 | 36.00 | 34.40 | 34.40 | 30.75 | 30.00 | 34.36 |
| 1904 | 32.12 | 34.00 | 36.00 | 36.40 | 34.63 | 32.62 | 35.00 | 37.00 | 40.40 | 40.00 | 44.25 | 46.13 | 37.40 |
| 1905 | 51.94 | 53.65 | 47.40 | 43.93 | 43.74 | 40.75 | 43.00 | 50.24 | 46.80 | 49.37 | 50.37 | 47.67 | 47.40 |
| 1906 | 49.33 | 49.25 | 45.60 | 44.00 | 41.50 | 44.20 | 43.88 | 44.38 | 43.20 | 42.50 | 44.43 | 45.55 | 44.82 |
| 1907 | 46.90 | 48.30 | 49.75 | 49.25 | 46.90 | 47.00 | 46.80 | 44.56 | 41.00 | 41.75 | 38.60 | 31.50 | 44.36 |
| 1908 | 37.60 | 36.63 | 36.19 | 35.40 | 34.19 | 34.06 | 34.55 | 36.53 | 37.63 | 35.95 | 39.13 | 42.75 | 36.63 |
| 1909 | 41.25 | 36.94 | 37.40 | 38.63 | 40.06 | 44.15 | 43.06 | 48.25 | 47.70 | 49.50 | 51.31 | 49.45 | 43.98 |
| 1910 | 47.31 | 40.69 | 43.60 | 41.00 | 40.19 | 40.20 | 39.63 | 40.13 | 43.45 | 43.31 | 47.20 | 42.50 | 42.42 |
| 1911 | 41.85 | 40.21 | 39.85 | 38.88 | 38.25 | 40.50 | 40.75 | 42.50 | 42.63 | 42.38 | 45.40 | 44.13 | 41.45 |
| 1912 | 44.90 | 45.75 | 51.56 | 52.00 | 55.30 | 55.88 | 58.85 | 55.13 | 59.75 | 57.00 | 55.69 | 54.63 | 53.87 |

(a) Base prices for 60 per cent. zinc ore.

*Montana.*—Zinc ore production in 1912 was 40 per cent. less than in 1911. This was on account of the idleness of the Elm Orlu mine, which was one of the two largest producers in the State in 1911. The first 500-ton unit of the new 1,000-ton concentrator of the Butte & Superior Co. was started in June, and the second one later in the year. Additions in progress at the close of the year to both the mill and the flotation plant, will considerably increase the capacity in 1913. Previous to the completion of the new mill the ores from the Butte & Superior mine were treated at the Basin concentrator.

According to D. C. Jackling, most of the fundamental difficulties have been solved, and it now remains only to ascertain the most economical rate of output. An extraction of 80 per cent. of the zinc blende is now accomplished. Early in 1913, zinc-ore concentrates were made at the rate of 5000 tons per month (2,500 tons of zinc). It is estimated that 300 lb. of zinc can be recovered from 1 ton of crude ore, at a cost of 4 cents per pound.

*Nevada.*—According to the U. S. Geol. Survey, shipments from Clark and Lincoln Counties, in 1912, included ores containing 2335 short tons of zinc, and concentrates containing 4327 short tons. This was more than three times the output of 1911.

*New Jersey.*—The Franklin Furnace mines of the New Jersey Zinc Co. produced an increased tonnage in 1912. According to the State Geologist, the concentrating mills treated 363,588 short tons of crude ore, yielding 298,901 tons of concentrates. An additional 95,997 tons of crude ore were shipped elsewhere, making a total ouput of 459,585 short tons, compared with 374,064 tons in 1911. The metallic contents included 69,755 tons of zinc in 1912, against 77,445 tons in 1911. Of the total output of concentrated ore, only about 50,000 tons is smelted into spelter, the remainder being consumed in the preparation of zinc oxide.

*Oklahoma.*—According to the U. S. Geol. Survey, the quantity of zinc carbonate and silicate sold in 1912 was only 92 tons, valued at $2550. Most of this concentrate came from the Peoria district, where little mining was done in 1912. Shipments of sphalerite concentrates in 1912 amounted to 12,129 tons, valued at $494,379. Of this output, 250 tons came from the Arbuckle Mountain region, Murray County, in southern Oklahoma, 1621 tons from the Quapaw district, and 10,258 tons from the Miami district.

Miami District (By L. C. Church).—Generally satisfactory conditions prevailed in 1912 in the Miami district. Drilling was carried on from the Neosho River, 5 miles southwest of the camp, to the Kansas line, 5 miles northeast, and new ore deposits were reported. New mills are in process of erection for the Church-Mabon Co., the Prairie Mining Co., the Miami Lead & Zinc Co., the Cactus Mining Co. and the Grey Top Mining Co.

SHIPMENTS OF CONCENTRATED LEAD AND ZINC ORE.
(Miami District, Okla., 1912.)

| Name of Mine. | Blende, Lb. | Value. | Galena, Lb. | Value. | Total Value Zinc and Lead Sulphides. |
|---|---|---|---|---|---|
| Church-Mabon[1] | 4,267,590 | $82,301 | 2,234,510 | $67,379 | $149,680 |
| Turkey Fat | 4,114,965 | 90,237 | 1,541,960 | 40,930 | 131,168 |
| Emma Gordon | 3,545,950 | 51,466 | 2,182,810 | 60,744 | 112,210 |
| King Jack | 2,328,500 | 53,724 | 515,580 | 14,003 | 67,727 |
| Chapman-Lennan[2] | 1,725,350 | 31,814 | 921,980 | 25,665 | 57,480 |
| New State | 1,722,650 | 34,308 | 334,420 | 8,987 | 43,296 |
| Buckeye | 1,010,960 | 24,206 | 44,260 | 1,204 | 25,410 |
| Miscellaneous[3] | 1,761,190 | 38,927 | 467,340 | 12,130 | 51,057 |
| Totals | 20,477,155 | $406,986 | 8,342,860 | $231,045 | $638,031 |

[1] Second mill completed in July. Third mill nearing completion.
[2] Mill completed in June.
[3] Includes Sullivan, Old Chief, Midas, Golden Hen and Mizpah—the latter mill completed in November.

The steady growth of the camp has been encouraging and hopes are entertained that in 1913 the production for 1912 will be doubled.

Arbuckle Field (By J. I. Blair).—The new Arbuckle zinc field, situated 8 miles southwest of Davis and in the heart of the Arbuckle Mountains in Murray County, southern Oklahoma, began to be prospected and developed immediately after the last allotment of the Indian lands. Since that time several cars of surface carbonate ore have been shipped and a few cars of blende in the form of concentrate.

The country is a rolling plateau, reaching an elevation of 1400 ft., formed by folded and faulted gray limestone, known as the Arbuckle limestone which is 6000 to 8000 ft. thick. This limestone lies in regular beds that dip and crop on the surface, rendering the country unfit for agricultural purposes and poor for grazing land. These tracts are destitute of timber but where porphyry hills are found they are covered with a good quality of heavy oak timber.

Of the minerals that have been found limonite is the most abundant. This ore occurs in regular strata interbedded with the limestone and is of good quality. It measures from 1 to 4 ft. thick, but is not traceable for any distance. Zinc minerals occur in brecciated limestone in beds and in irregular deposits which outcrop over the entire section. No important discoveries of lead have yet been made. Besides these ores, molybdenite, scheelite and greenockite are found in small quantities; the latter occurs only associated with the zinc minerals.

The zinc ore is mined by open pits. It is a fairly clean ore and occurs as the sulphide at the grass roots, assaying 4 to 10 per cent. zinc as mined, an approximate assay of this ore being as follows: ZnS, 14 per cent.; $CaCO_3$,$MgCO_3$, 70 per cent.; $BaCO_3$, 5 per cent.; Fe and Cd, 3 per cent.; $SiO_2$, 5 per cent.; not determined, 3 per cent.

The company developing the properties in the vicinity of the Hope-Schoeber district has a 75-ton mill which has had a varied experience due to the presence of witherite, which, owing to its high specific gravity, follows the blende. At this mill is a pile of tailings containing about 1000 tons which assay 6 per cent. zinc. At present the mill is being remodeled to treat these tailings. A typical day's mill run is as follows: 75 tons of 6 per cent. ore yield 4.5 tons of concentrates, gross value $200. Cost of production: Transportation to railroad at $2.75 per ton, $12.40; freight to smeltery at $2.25 per ton, $10.10; royalty at 12.5 per cent., $25; operating expenses (labor), $30; powder, caps and fuse, $4; fuel (wood) at $2.50 per cord, $9; incidentals, $1.50; total cost, $92; net profit $108. The high royalty is due to the fact that the present owners hold a sublease. The figures given for fuel are misleading in that

but a limited supply of wood is available and when this is exhausted the fuel question will become a serious proposition.

*Tennessee.*—The American Zinc, Lead and Smelting Co. actively developed its properties during 1912, and reports that large bodies of ore were disclosed. A shaft was sunk and a large amount of churn and diamond drilling was done to outline the ore-bodies. The mill and machine shop are partially built and should be completed in the near future. A large amount of development underground has already been done, so that on completion of the mill at Mascot, the mine will be ready for operation. Power plant, spur tracks, dwelling houses, a boarding house and other necessary buildings for a mining camp have been or are being built. Another zinc-smelting concern has become interested in the district, and is prospecting the Edes, Mixter & Heald property at Jefferson City.

*Utah* (By E. R. Zalinski).—During the last part of 1912, between 1500 and 2000 tons of zinc ore monthly were shipped from Tintic. A large part of this went to smelteries in the Middle West. A new freight rate of $7.30 per ton on $30 ore to the Kansas zinc smelteries, as compared to a former rate of $9.50, went into effect Sept. 16. The production from Park City by the Daly-Judge increased. The Daly West produced zinc concentrates. The Grasselli plant at Park City, and an auxiliary plant built to treat tailings along Poison Creek, did not operate. Numerous small tailings mills made occasional shipments of zinc concentrates. The Daly-Judge shipped zinc middlings to the Huff electrostatic plant of the United States Company at Midvale. This plant also treated other custom ore and ore from the company's own mines at Bingham. At Tintic the May Day mine was the heaviest shipper of zinc ore; during the fiscal year ended Mar. 31, 1913, the company received $90,113 from 2750 tons of zinc ore, of which about one-fifth was mined by lessees, whose contracts expired at the end of the year. The Gemini mine is also becoming prominent as a zinc producer.

*Virginia.*—According to the U. S. Geol. Survey, the output of zinc, calculated as spelter, was 249 tons, compared with 1032 tons in 1911; the 1912 yield was contained in 4585 tons of mixed ores from the Austinville, Bertha, and Little Wythe mines in Wythe county. The Austinville mine produces both lead and zinc and the Bertha mine zinc only. The output is from both ore and old tailings, which are concentrated. A small tonnage of ore was also shipped crude. Part of the concentrates and soft ore were treated in the Austinville oxide plant and the remainder was shipped. At the Little Wythe mine, near Cripple Creek, the principal production is of iron ore, but as zinc sulphides are encountered in streaks they are mined, hand-sorted, and shipped crude to zinc smelters.

*Wisconsin* (By J. E. Kennedy).—The net tonnage of zinc ore shipped to smelteries from the Wisconsin district in 1912 was 242,080,180 lb., an increase of 27,133,044 lb. over the shipment of 1911. The gross tonnage from mines was 198,818,210 lb., of which amount approximately 9,000,000 lb. was carbonate ore. The tonnage of lead ore shipped was 8,241,350 lb., a decrease of 739,665 lb., while the shipment of sulphur ore, 40,266,570 lb., showed an increase of 11,327,130 lb. The accompanying table gives the shipment of zinc ore by camps for 1911 and 1912.

WISCONSIN-ILLINOIS ZINC ORE SHIPMENTS.

| | 1911. | | 1912. | |
|---|---|---|---|---|
| | Gross from Mines. | Net to Smelteries. | Gross from Mines. | Net to Smelteries. |
| | Pounds. | Pounds. | Pounds. | Pounds. |
| *Wisconsin:* | | | | |
| Highland | 9,612,430 | 9,143,130 | 8,288,300 | 8,103,700 |
| Linden | 16,945,482 | 753,150 | 15,199,060 | 2,355,150 |
| Harker | 7,798,995 | 7,469,525 | 12,799,180 | 8,646,230 |
| Mineral Point | 2,314,169 | 36,838,929 | 1,466,400 | 39,236,740 |
| Montfort | 3,011,060 | 1,008,120 | 2,298,160 | 1,493,160 |
| Livingston | 12,979,290 | 285,000 | 18,987,250 | 665,000 |
| Rewey | 6,111,660 | 1,765,120 | 2,530,000 | 2,339,000 |
| Platteville | 29,315,420 | 36,190,240 | 31,211,950 | 27,207,610 |
| Cuba City | 4,384,090 | 4,056,700 | 7,918,850 | 10,266,600 |
| Benton | 52,188,830 | 13,873,610 | 48,295,180 | 32,379,740 |
| Hazel Green | 39,469,020 | 12,052,220 | 34,838,900 | 17,196,500 |
| Shullsburg | 9,067,800 | 1,478,220 | 25,372,750 | 22,342,900 |
| Dodgeville | 460,910 | 460,910 | 1,552,330 | 1,390,930 |
| *Illinois:* | | | | |
| Galena | 21,287,980 | 26,313,570 | 31,321,870 | 25,194,950 |
| Totals | 214,947,136 | 151,688,444 | 242,080,180 | 198,818,210 |

The year 1912 recorded the highest level of prices ever attained for zinc ore. The base price of 60 per cent. zinc ore steadily advanced from $44 per ton at the beginning of the year to $60 per ton at the end of July. The market then weakened somewhat, as it usually does at that time of the year, and the base price fluctuated between $52 and $62 per ton during the remainder of the year. The highest premium price paid was $64 per ton.

High prices and good profits stimulated prospecting in all parts of the district. A large number of abandoned mines were reopened and leased lands were redrilled. Shullsburg showed the largest increase in ore production due to the large consistent output of the Winskell mine, owned by the Wisconsin Zinc Co. The Crahall mine, operated by the Field Mining Co., in the New Diggings Township, developed a lode of high-grade zinc ore, turning out raw concentrates assaying over 55 per cent. metallic zinc. At Platteville the East End mine proved to be a continuation of the Klar-Piquette range and made quick return to the Wisconsin Zinc Co. of the purchase price of $75,000. At Hazel Green

the big run of the Cleveland mine was struck ahead on the Scrabble Creek leasehold by the Vinegar Hill Zinc Co. The Frontier added another big mine in the Hird property at Benton. A number of good drilling prospects were proved at Platteville, Benton, Cuba City and Shullsburg. Ten concentrating mills and one roasting plant were constructed and rebuilt during the year. The Interstate Light & Power Co. extended its power transmission lines throughout the district.

PRODUCTION OF ZINC IN EUROPE AND AMERICA. (a)
(In metric tons.)

| Year. | Austria. | Belgium. | France. | Germany. | Holland. | Italy. | Russia. | Spain. | United Kingdom. | United States. | Totals. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1898 .. | 7,302 | 119,067 | 37,155 | 154,867 | 6,700 | 250 | 5,664 | 6,031 | 28,387 | 103,514 | 468,937 |
| 1899 .. | 7,192 | 122,843 | 39,274 | 153,155 | 6,235 | 251 | 6,331 | 6,184 | 32,322 | 117,644 | 491,331 |
| 1900 .. | 6,742 | 119,315 | 36,305 | 155,799 | 6,845 | 547 | 5,963 | 5,611 | 30,207 | 111,794 | 465,438 |
| 1901 .. | 7,558 | 127,170 | 37,600 | 166,283 | 7,855 | 511 | 6,090 | 5,354 | 29,877 | 127,751 | 516,049 |
| 1902 .. | 8,309 | 124,780 | 36,300 | 174,927 | 9,910 | 485 | 8,280 | 5,569 | 40,244 | 143,552 | 552,356 |
| 1903 .. | 8,949 | 131,740 | 37,416 | 182,548 | 11,515 | 126 | 9,901 | 5,134 | 44,110 | 143,792 | 569,971 |
| 1904 .. | 9,159 | 137,323 | 41,600 | 193,058 | 12,895 | 189 | 10,607 | 5,887 | 46,218 | 164,921 | 621,857 |
| 1905 .. | 9,204 | 142,555 | 43,200 | 198,208 | 13,550 | 5 | 7,520 | 6,184 | 50,125 | 183,014 | 653,565 |
| 1906 .. | 10,711 | 148,035 | 46,536 | 205,691 | 14,650 | 69 | 9,610 | 6,209 | 52,587 | 204,548 | 698,646 |
| 1907 .. | 11,208 | 154,492 | (c)49,733 | 208,195 | 14,990 | 88 | 10,409 | (c)6,000 | 55,595 | 226,398 | 737,108 |
| 1908 .. | 12,770 | 161,940 | 47,880 | 216,490 | 17,257 | (d)100 | 9,960 | 6,357 | 54,473 | 190,933 | 718,160 |
| 1909 .. | 12,638 | 167,100 | (c)49,718 | 219,766 | 19,548 | (b) | 7,949 | (c)6,400 | 59,350 | 241,730 | 784,199 |
| 1910(f) | 13,305 | 181,745 | (c)51,527 | 227,754 | 20,975 | (b) | 8,128 | (c)6,604 | (e)63,587 | 251,348 | 824,973 |
| 1911 .. | 15,766 | 198,230 | 57,110 | 235,776 | 22,734 | (b) | 9,652 | 6,333 | (e)67,907 | 268,378 | 881,886 |
| 912 .. | 19,096 | 205,940 | 65,565 | 271,064 | 23,932 | (b) | 11,176 | 6,500 | 57,231 | 316,368 | 976,872 |

(a) From the official statistics of the various Governments except 1906 to 1911 inclusive, for which years the figures reported to Henry R. Merton & Co. have been used where the official statistics were unavailable. In addition to the production reported in this table, Aust alia produced 286 long tons in 1903, 299 in 1904, 544 in 1905, 1008 in 1906, 980 in 1907, and 1086 in 1908. (b) Included in Austria. (c) An approximate separation of the total which is reported for "France and Spain." (d) Estimated. (e) Includes 508 and 1000 tons from Australia. (f) *Eng. and Min. Journ.*

## Zinc Ore Mining in Foreign Countries

*Algeria.*—Zinc ore exported in 1912 is reported by the U. S. consul at Algiers, as being valued at $2,446,082, compared with $1,915,525 in 1911. The production of zinc ores in 1912 is officially reported at 84,495 metric tons. According to *Echo des Mines*, the Aïn-Arko mines produced 9564 tons of ore in 1912, of lower grade than before. The same company will also operate the Aïn-Barbar mines, one of the most important in northern Africa, and will erect a smeltery at the mines.

*Australia.*—According to the annual report of the Department of Mines of New South Wales, in which state practically all the zinc ore of Australia is mined, the output in 1912 included 2545 long tons of spelter, besides which 520,518 tons of blende concentrates, estimated to contain 194,214 tons of zinc, were exported. The combined value of zinc and concentrates in 1912 was £1,766,242, compared with £1,414,980 in 1911.

The Broken Hill mines in 1912 hoisted 28,057 tons of oxidized and

1,611,602 tons of sulphide ores, a total of 1,639,659 tons, compared with 1,484,397 tons in 1911, and with 1,652,891 tons in 1907, the record year.

The Broken Hill Proprietary Co., by means of the zinc flotation plant, treated 143,625 tons of tailings from ore and 172,816 tons of tailings from dumps, producing 88,008 tons of zinc concentrates, containing 40,947 tons of zinc, 6184 tons of lead, and 1,135,331 oz. of silver. The slimes treatment plant was completed and put into operation for some time during 1912. This plant produced 8681 tons of concentrates, having an average assay value of 35.93 per cent. zinc, 17.81 per cent. lead, and 31.69 oz. silver per ton.

The Sulphide Corporation, Ltd., disposed of 71,040 tons of zinc concentrates of an average assay value of 45 per cent. zinc, 9 per cent. lead, and 15 oz. silver per ton.

The Minerals Separation Company's plant closed down in June, 1911. The output of this company since the inception of operations is as follows: Zinc concentrates, 211,235 tons, containing by assay: Silver, 2,840,301 oz.; lead, 19,407 tons; and zinc, 97,954 tons. The total value of the metallic contents is given as £1,825,071.

The Amalgamated Zinc (De Bavay's), Ltd., experienced a very successful year. The tailings treated totalled 538,086 tons, the average assay value being: Zinc, 16.6 per cent.; silver, 4.6 oz.; and lead 3.9 per cent. The zinc concentrates produced totalled 148,013 tons, the average assay value being: Zinc, 48.7 per cent.; silver, 8.9 oz.; and lead, 6.1 per cent. The lead concentrates produced amounted to 2053 tons, the average assay value being: Zinc, 15.3 per cent.; silver, 35.9 oz.; and lead, 57.7 per cent.

The Zinc Corporation, Ltd., treated 345,425 tons of tailings (assaying: Zn, 14.41 per cent.; Pb, 5.55 per cent.; Ag, 6.94 oz.) and recovered therefrom 85,354 tons of zinc concentrates (assaying: Zn, 47.21 per cent.; Pb, 7.36 per cent.; Ag, 12.53 oz.) and 10,881 tons of leady concentrates (assaying: Zn, 14.80 per cent.; Pb, 57.90 per cent.; Ag, 32.17 oz.).

At the British mine it is stated that the Elmore plant is to be replaced by a Minerals Separation plant. During the year 27,298 tons of concentrates, assaying 40.5 per cent. zinc, 11 per cent. lead, and 11 oz. silver per ton were produced.

*Belgium.*—Imports of zinc ore into Belgium through the port of Antwerp during 1912, and destined to all the works in the country, were as follows, in metric tons: From Sardinia, 84,549; Spain, 65,194; France, 36,181; Algeria and Tunis, 78,417; England, 10,167; Sweden, 21,398; Greece, 14,243; Chile, 8183; Australia, 257,205; Japan, 24,572; Siberia, 15,613; other countries, 49,990; total, 665,712 tons. Of this total, the Vieille-Montagne Co.'s share was 215,317 tons, or about one-third.

In the imports the large tonnage of zinc concentrate from Broken Hill, New South Wales, is noticeable. One of the most important zinc enterprises of the Liège district is that of the Vieille-Montagne Zinc Co., at Angleur. The company's annual report shows that its 14 plants produced 107,526 metric tons of crude zinc in ingots, while its rolling mills turned out 78,099 tons, and its mills for producing zinc-oxide 11,687 tons. There were 124,634 tons of ore extracted from the company's mines, all situated in other countries. Of this amount, 113,482 tons was zinc ore and 11,152 tons lead ore.

The total production of the country in 1912 is officially reported at 205,940 metric tons of spelter, and 49,120 tons of sheets. No zinc ore was mined in Belgium during 1912, and only 836 tons in 1911.

The roasting of zinc blende in Belgium is generally accomplished by the Eichhorn muffle. Each oven is divided into four independent divisions. The Rhenamia type, common in Germany, has two divisions. The air is preheated and a temperature of 900 to 1000° is maintained in the muffle. With the average blende, containing 25 per cent. sulphur, the roasted ore is about 87 per cent. of the original weight. In a few Belgian works, where both blende and pyrites are roasted, the de Laplace combination oven has been introduced. This consists of a series of superimposed shelves like the ordinary pyrites kiln, but which can be changed into a muffle furnace by the aid of a hearth. The fuel consumption amounts to 11 per cent. of the blende; in the Eichhorn type it is usually 15 per cent. Mechanical roasters have not been a success. In some works the waste heat from the roasting ovens is utilized to partially coke the coal employed. The resultant gas is burned beneath the muffles, with coke.

*Greece.*—The production of zinc ore at Laurium in 1912 was 28,626 metric tons, against 30,020 tons in 1911. Owing to diminishing richness of the ore, the average net returns remained at 101 francs per ton, as in 1911, in spite of the higher price for zinc that prevailed in 1912.

*Indo China.*—According to *Echo des Mines*, the output of zinc ores during 1912 amounted to 28,377 metric tons; the leading contributors were as follows:

| | Calamine. | Blende. |
|---|---|---|
| Mining Co of Trang Da | 12,180 | 1,250 |
| Mining Co. of Tonkin | 6,125 | 440 |
| Mining Co. of Than Mai | 200 | 1,195 |
| Mining Co. of Yen Linh Brizard | 186 | 515 |
| Mine Prospecting Co. of Tonkin | 3,614 | 700 |

*Japan.*—The output of zinc ore in 1911 was 23,584 metric tons, most of which was exported to Europe, while spelter and zinc white were imported to the amounts of 4000 tons and 75 tons respectively.

Two concerns are erecting zinc smelters: The Mitsui Busan Kaisha, at Omuta, and another company at Osaka; at present there are no other spelter reduction works. Zinc white is made at Ninami, Shinagawa, Tokyo and Osaka.

*Mexico.*—Zinc ore is mined at Charcas, and further north around Salado. The Empire Zinc Co. owns La Bufa mine at Charcas. It was formerly a lead-silver mine, abandoned on account of the burdensome zinc. Near Salado, carbonates running 30 to 45 per cent. zinc were formerly shipped to Kansas City, but little work is now being done.

Exports from Mexico during the fiscal year ended June 30, 1912, included 1050 metric tons of spelter consigned to the United States, and 42,257 tons of zinc ore, valued at 883,794 pesos, consigned as follows: Germany, 13,244 tons; Belgium, 15,199 tons; United States, 13,741 tons; Great Britain, 67 tons; France, 5 tons.

*Norway.*—Zinc is at present refined at the Usines Electrochimiques de Hafslund, at Sarpsborg, and also at Ilens Smelteverk, Trondhjem. The production of the former was 6500 tons in 1911; the latter was idle in 1912.

Within recent years, extensive examination of zinc deposits has been undertaken in the neighborhood of Kristiania, by two German firms. In this district are found extensive but poor deposits of this ore. Attempts to concentrate the ore mechanically have hitherto been unsuccessful. Experiments are therefore now being made for direct extraction of zinc from the ore by electrolytic methods. A plant for the extraction of zinc is now built at Sarpsborg, and in 1912 about 9000 tons of zinc was shipped.

*Peru.*—According to the *Mining Journal*, the following exports of zinc ore, almost exclusively the product of the Huanchaca Company, have been reported:

| | Metric Tons. | Value in Francs. |
|---|---|---|
| 1908 | 1 | 684 |
| 1909 | 183 | 52,650 |
| 1910 | 11,897 | 870,017 |
| 1911 | 9,798 | 744,980 |
| 1912 | 9,010 | 664,490 |

*Spain.*—According to *Revista Minera*, 44 mines having a combined area of 551 hectares and employing 2243 men, in 1912 produced 162,140 metric tons of zinc ore, valued at 6,742,493 pesetas at the mines. Exports of zinc ore in 1912 were 111,694 tons, and 127,623 tons in 1911.

*Tunis.*—The tonnage of zinc ores exported has not varied much from 33,000 metric tons for the past 5 years, although the average metal contents has been improved by the practice of calcining the calamine ores.

## Progress in the Metallurgy of Zinc in 1912

In the metallurgy of zinc a great deal of experimental work is going on all the time; there are steady improvements in the details of conventional practice, occasionally new developments are designed and put successfully into operation for the treatment of special kinds of ore, but there is seldom anything of revolutionary character or widespread bearing to chronicle.

Zinc smelting was begun in Japan in 1912 at Amagasaki, near Osaka, where two furnaces, each comprising 60 retorts, were in operation. A plant of three furnaces, each comprising 120 retorts, is in course of erection near Kasaoka, on Konoshima Island, in the Province of Okayama. This plant is expected to be ready for operation early in 1913. At both these plants, which are considered by the Japanese to be of experimental character, the furnaces are regenerative and have the Rhenish form of retorts.

*Roasting-furnaces.*—In Europe, furnaces of the old Maletra type, but greatly improved, as exemplified in the designs of de Laplace, are being built more and more. The object in Europe is to economize fuel, which there is relatively expensive. In America, fuel is cheap, and we do not have to pay so much attention to ecomony in its use. Consequently, our smelters in the natural-gas field adhere to the Zellweger furnace, although that is frightfully wasteful of fuel. In the coal fields, everybody builds the old Hegeler furnace, which is clumsy and only semi-mechanical, because apparently nobody knows what else to do. The smelters in the natural-gas fields are now paying the penalty for their neglect to develop an economical furnace, the cost of natural gas having risen to so high a figure that no longer may it be wasted with impunity. This led, during 1912, to calamine ores being accepted gratefully upon a low margin for smelting, no roasting being necessary in their case, while for blendes, high margins were demanded and obtained. Several of the smelters are firing their roasting furnaces with oil, but this does not help matters much, because oil itself is a relatively costly fuel in Kansas and Oklahoma. Some gratifying experiments with a furnace of the McDougal type were made in 1912, and this may become the furnace of the future, combining full mechanical qualities with the ability to roast the ore with a minimum consumption of fuel and delivery of a gas of sufficiently high tenor in sulphur dioxide for sulphuric-acid manufacture.

*Distillation Furnaces.*—A similar difference in tendency, governed by conditions, obtains with respect to the distillation furnace. The costly coal of Europe necessitates careful attention to economy in its use, *i.e.*, heat recuperative furnaces of elaborate construction. There is some

progress in this direction in America, but it is not yet general, probably because it does not have to be. American smelters continue to prefer the long furnace with the small cylindrical retorts. Furnaces of the Rhenish type are in use only at Pueblo. American metallurgists who have worked with both express a preference for the best type of the furnaces used in Illinois. At the new Hillsboro works of the American Zinc Co., the furnaces are fed with air delivered by blowers. Heat recuperation is effected through the medium of steam boilers. In Europe we find such modern constructions as those of Schmidt & Desgraz, Dor-Delattre, and Folliet.

An example of the European tendency in furnace construction is afforded by the furnace designed by A. Folliet, and erected by him at the Corphalie works in Belgium. This furnace is of the reversing regenerative type, but differs from the ordinary in that the movements of the air and gas are controlled independently. The air regenerators are in the lower part of the massive and the gas regenerators are at one end, and products of combustion being divided so as to pass out through these respective parts. The preheated gas and air pass through canals erected upon the roof of the furnace, from which they enter the combustion chamber in a downward direction. The furnace is divided not only by a longitudinal wall, but also by numerous transverse walls, the massive being thus divided into a plurality of small furnaces, so to speak. In his patent specification, Mr. Folliet says:

> In operation the furnace possesses numerous advantages. The control is excellent and the retort chambers are not subject to temperature fluctuations. Moreover, the temperature maintained is uniform throughout the entirety of the furnace, irrespective of the length thereof. Any pair of opposite chambers may be regulated or cut off independently of the others, without affecting in any way the operation of the remainder of the furnace. There is no danger of a formation of darts or jets of flame or sudden or uneven combustion, even when forced draft is employed. These results are due to the sectioning of the combustion chambers and the arrangement so that the air and gas enter each chamber independently of the other chambers of the same series, and partly to the special formation and arrangement of the groups of air and gas ports for the several chambers. Further, owing to the ability to instantly vary the proportions of the products of combustion passing through the air and gas regenerators, all danger of explosions is removed. All of the parts of the furnace are readily accessible during operation.

In a personal communication, Mr. Folliet tells me that three of these furnaces had been installed in the Corphalie works, the capacity of each being 11,000 to 12,000 kg. of ore per 24 hours. The consumption of coal (anthracite fines of 5-15, or 6-20-mm. size) is 850 to 900 kg. per ton of ore, and the extraction of zinc is 91 to 92 per cent. of the contents of the ore. This is unusually low fuel consumption. I may add that the position of the gas and air flues and gas regenerative chambers in the Folliet furnace tends to reduce the loss of heat through roof and end radiation. The Folliet furnace is supplied with gas from independent producers of Mr. Folliet's design, which resemble some of the standard American cylindrical gas producers.

Mr. Pape, of the International Zinc Co., Hamburg, Germany, experi-

mented at Billwärder during 1912 with a furnace comprising vertical retorts, but as far as I have heard he has not yet come to any conclusive results.

An interesting feature of 1912 was the installation of a Saeger furnace charging and discharging apparatus by the National Zinc Co., at Bartlesville, Okla. This apparatus is in use at Silesia, but heretofore has not been introduced in the United States; nor in fact does mechanical charging exist anywhere else, although the New Jersey Zinc Co. several years ago tried it experimentally.

*Heat Balance of a Siemens' Distillation Furnace.*—In *Metallurgie*, Nos. 10, 11 and 12, for 1912, Dr. F. Eulenstein presented a remarkably competent and painstaking study of the heat balance of a Siemens' zinc distillation furnace. The paper may be commended to anyone who desires to make an analytical study of the details of zinc distillation. Dr. Eulenstein accounts for the heat supplied to such a furnace as follows: Lost in the chimney gas, 50.85 per cent.; discharged in the retort residues, 2.67 per cent.; in the spelter, 0.45 per cent.; in discarded retorts, 0.19 per cent.; in the gas issuing from the condensers, 2.76 per cent.; consumed in the endothermic reaction in the retorts, 10.96 per cent.; lost by radiation and conduction, 32.12 per cent. Dr. Eulenstein points out, however, that the loss by radiation is not wholly a loss, inasmuch as part of the heat radiated from the front of the furnace is necessary to maintain the condensers at the proper temperature for the performance of their duty. This remark illuminates the experience of some experimenters with electric furnaces, who have found it necessary to heat their condensers by external means.

*The Use of Salt.*—The use of salt in small quantities placed in the mouth of the retort or in the inner end of the condenser, for the purpose of reducing the production of blue powder, has continued to be practiced by the Central Zinc Co., at Seaton-Carew, England; and has been tried also at the smelting works at Cockle Creek, New South Wales. From both places come reports of successful results, the production of spelter as direct metal being considerably increased and the production of blue powder being materially decreased. The salt is used in extremely small quantities as compared with the total charge of the retort. This, of course, is a different thing from the admixture of a small amount of salt with the charge, which has long been practiced. The beneficial effect of the salt at Seaton-Carew and at Cockle Creek is supposed to be due to the action of the salt vapor in removing the thin film of oxide coating minute pellicles of condensing zinc, thus allowing them to coalesce and to form fluid zinc.

*Igneous Concentration.*—A good deal of attention has been given to

the igneous concentration of zinc, *i.e.*, the burning it out of the ore and collecting the fume. Of course, this is just what is done in the old Wetherill process of making zinc oxide, but in that process the production of an oxide of proper color is an essential condition. As a mere matter of concentration, the color of the oxide is quite immaterial. The concentration of zinc in this way has long been practiced by the New Jersey Zinc Co. in Virginia, the impure oxides being passed on to the spelter furnaces for reduction.

The development of the Pape process for the extraction of zinc from the Oker slag drew renewed attention to processes of this kind. Heretofore, Mr. Pape has been able only to treat slag, but I am informed that during 1912 he succeeded in adapting his process to the direct treatment of ore. Mr. Blum, in a small plant in Mexico, has experimented with an adaptation of the Huntington-Heberlein process for the same purpose. Wilhelm Witter, of Hamburg, Germany, has pursued a somewhat different line, aiming to drive off the zinc in a reverberatory furnace. A large furnace for this purpose was erected in 1912 at the Binsfeld-Hammerhütte, at Stolberg, where a lead slag containing 8 to 10 per cent. zinc was to be treated.

Edward Dedolph several years ago made experiments at the Blue Bell mine, in British Columbia, with a revolving cylinder for the burning off of the zinc of raw blende. I understand that his experiments have been repeated by the Metallurgische Gesellschaft, of Frankfurt-am-Main. Anyway, during 1912 that company acquired the rights to Mr. Dedolph's patents. The interest in the igneous concentration of zinc is stimulated by the desire to obtain an enriched and relatively pure product for electric smelting.

*Electric Smelting.*—A good deal of experimental work in electric smelting was done during 1912, among others by Specketer, Thierry, Cote & Pierron, Johnson and Petersen; and by the Vieille Montagne Company and the Canadian Department of Mines. At Trollhattan and Sarpsborg, in Scandinavia, electrothermic spelter was produced commercially, and enlargement of the works was undertaken. The results in the smelting of 537 metric tons of ore in 1911 were reported by F. W. Harbord. According to him the average power consumption per ton of ore was 2078 kw., this relatively high figure being explained to a large extent by the necessity for resmelting 2 tons of blue powder for each ton of new ore. Some of the conditions entering into electric zinc smelting were outlined in a paper presented by me to the Canadian Mining Institute, at Toronto, in March, 1912.[1] In this paper I indicated that the avoidance of blue powder to be resmelted is a necessary condition

[1] *Eng. and Min. Journ.*, July 6, 1912.

in making electric zinc smelting a commercially successful process; that the formation of the excessive proportion of blue powder, commonly experienced, was due to impurities in the gas and vapor, including an unpermissible percentage of carbon dioxide; and that the reduction of the power consumption of 1200 kw. per ton of ore would be a brilliant achievement.

I have been informed that Specketer, Thierry and Johnson have succeeded in avoiding an excessive condensation as blue powder, finding purity of the gas and vapor to be an essential condition, and although I am unable to verify these statements and this conclusion from personal observation and experimentation, both of the latter on my own part have prepared me to accept their probable truth. I am informed also of some well progressed experimental work wherein the smelting of ore containing 40 to 42 per cent. zinc has been done with a power consumption of only 1175 to 1200 kw.

In the United States, W. McA. Johnson, who has been engaged on this problem for seven or eight years, is certainly further ahead than anybody else. He has informed me of the production at Hartford, Conn., of several hundred pounds of spelter per day in campaigns lasting several days, and during 1912 has made perhaps a dozen tons of spelter in the aggregate. The Butte & Superior Copper Co. did some experimentation with the Peterson furnace, with more or less promising results, and toward the end of the year was contemplating a 10-day run at the rate of 2000 lb. of ore per day. The New Jersey Zinc Co. inaugurated some experimental work in its laboratory at Palmerton, Penn.

In Europe, electrothermic spelter was produced at Trollhattan and Sarpsborg. Some tonnage was also produced at Hohenlohehütte, Silesia, by the Imbert Process Co., but reports of what has actually been accomplished are still conflicting. The Imbert Process Co. has never given out anything about its operations. My private advices from Kattowitz are to the effect that after a great deal of costly experimentation, the process has been practically dropped at Hohenlohehütte. It has also been dropped by the Amalgamated Zinc Co., of Australia, which was looking into it. The Vieille Montagne Company experimented with an electric furnace at one of its smelteries. Cote & Pierron also resumed experimental work.

The experimentation in electric smelting is following two distinct lines: (1) The smelting of mixed ores, drawing off the gangue in the form of slag from the distillation furnace itself; (2) burning off the zinc in a separate furnace, collecting it as fume, and subjecting the fume alone to distillation in the electric furnace, the idea being that there are fewer complications with a relatively pure and high-grade product. The

relative merits of these two ideas have not yet been worked out. In short the whole subject is still in its infancy.

*Hydrometallurgical Processes.*—Hydrometallurgical processes fall under two heads: (1) Chemical and (2) electro-metallurgical. Processes of both types are on record as having been in commercial use, but nothing of either type has survived in regular practice. However, new proposals come by the scores and hundreds. Among the latest that have received attention, nothing much appears to have been accomplished with the widely advertised "bisulphite" process. The French process figured extensively in the newspapers, especially in British Columbia, in 1912, but tests of it that were made at Trail do not appear to have aroused any enthusiasm. Mr. Bretherton, in California, has been working upon his ammonia-zinc process, and is getting ready to make a trial of it upon a commercial, or semi-commercial, scale; his primary product is zinc oxide.

Mr. Keating, at Bully Hill, has been working upon the hydrometallurgical extraction of zinc and electrical precipitation of the metal from the solution. In an experimental plant of pretty good size, he has succeeded in rendering from 50 to 60 per cent. of the zinc of his ore soluble in water, by roasting very slowly at about 700° C. This is the best sulphating roasting that I ever heard of. Mr. Keating has succeeded in overcoming the main difficulties of electrolysis and has exhibited dense and compact cathodes of high purity and marvellously good appearance. The commercial prospects of this process are, however, still uncertain. At the Raritan Copper Works, Perth Amboy, N. J., experimental work with the Isherwood process was done during 1912. This is an offshoot, or a variation, of a process developed by Siemens & Halske, who also have succeeded in overcoming the electrolytic difficulty.

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No extended introduction to this bibliography is required, and it is necessary to repeat only the reasons for including it as usual in this volume. The Mineral Industry has included each year, under the special articles, a bibliography of the important literature relating to the subject covered in each article. The general topics of mining and engineering cannot, however, be included in such bibliographies and are therefore given in the following for the year 1912.

A selection of articles is classified under heads in alphabetical order, so that each subject is accessible to the busy man who wishes to review it in a short time. It is the aim of the author to give articles that are worth while, and that are connected with approved practice, but no exhaustive review is intended. Further, articles likely to be on file at the average mining center are given preference to others either in foreign languages or of small circulation. In order to express the true contents of the articles the original title is not always retained.

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### Chemistry

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Martin, Geoffrey. "Industrial and Manufacturing Chemistry, Inorganic." (1913, 726 pp., $6.00.)

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Mellor, J. W. "Modern Inorganic Chemistry." (1912, 250 pp., $2.20.)

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Lewis, J. V. "Determinative Mineralogy." (1913, 151 pp., $1.50.)

Phillips, A. H. "Text-book of Mineralogy." (1912, 699 pp., $3.75.)

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### Metallurgy

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GOWER, A. R. "Text-book of Experimental Metallurgy and Assaying." (1913, 178 pp., $1.50.)

GREENAWALT, WILLIAM E. "Hydrometallurgy of Copper." (1912, 504 pp., $5.00)

Gulliver, G. H. "Metallic Alloys. Their Structure and Constitution." (1913, 410 pp., $3.25.)

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HOOVER, THEODORE J. "Concentrating Ores by Flotation." (1913, 221 pp., $3.75.)

HUDSON, O. F. "Iron and Steel." With a section on Corrosion by G. D. Bengough. (1913, 184 pp., $2.00.)

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# RECENT ADVANCES IN THE APPLICATION OF GEOLOGY TO THE STUDY OF ORE DEPOSITS

By C. F. Tolman, Jr.

The rapid growth of the literature of applied geology is the best proof, and, in a rough manner, a measure of the advance in the application of the science of geology to American industries in general and to mining in particular. Fig. 1 from Mr. Brooks'[1] article on applied geology, showing the proportion of technical papers compared with those of a strictly scientific or educational nature, published by the United States Geological Survey, is an effective visualization of this recent growth.

The United States Geological Survey has been stimulated to this increased activity in the investigation, both theoretical and practical, of the science of ore deposits by the example of the larger mining companies in establishing "geological departments"or "geological corps" to plan mine development and guide the search for ore.

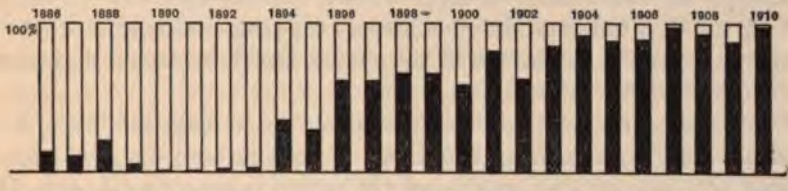


Fig. 1.—Percentage of Total Publication of the U. S. Geol. Surv. Relating to applied Geology.

Fifteen years ago had a stranger asked the shift boss at any of the large western mines for the office of the company geologist, he would have probably been referred to the company hospital or to the state insane asylum. Five years ago one would have found the office of the geologist in a corner of the assayer's laboratory or of the lounging room for the shift bosses. Now, in one case at least, the surveyor and engineer are allowed a corner in the geologist's drafting room.

The application of geology to mining is as broad as the science of geology and as varied as the activities of mining. The prevalent idea that the geologist's only function is to theorize as to the genesis of the ores, or perhaps to solve a fault problem, shows a lack of appreciation of the possibilities of the application of geology to a large proportion of the

[1] Brooks, A. H., "Applied Geology," *Journ. Wash. Acad. Sci.*, Vol. II, pp. 19–48, 1912.

engineering problems that may present themselves for solution to the miner. Is there a road to be constructed? The questions to be investigated may not only be those of grade, and yardage of the material to be excavated, but if the cuts are deep, and cross several formations at varying dips, the question of geological structure may be as important as that of grade. The majority of the 'bad' railroad cuts and tunnels of the west that I have examined could have been improved upon, had the companies employed the services of a trained geologist. If the wagon roads are to last, they must not only be properly graded and protected from erosion, but they must have a good foundation and a proper capping of road metal, and the geologist should be able to pick out the best combination of materials at hand for the latter.

Are dams to be built? If so, the civil engineer, picking out what seems to him to be a favorable site, will perforate the same with test drill holes. The geologist might have assisted him by designating any structural weakness of the rock foundation (such as faulting, stratification, or schistosity parallel to the stream channel), and thus reduced to a minimum the number of test pits necessary.

Are reservoirs to be built? An astonishing number of cases have been brought to my attention, where great care and engineering skill have been shown in the construction, while no attention has been paid to the rock foundation on which these structures rest. In one case a reservoir was built on top of a hill carved out of steeply dipping shales, and after the water was turned in, a portion of the shale slipped down hill carrying a part of the reservoir with it.

The detailed mapping of the rock structure underground may be of value not only in disclosing the structure of the ore-body, but also in locating the lines of rock weakness, the water bearing faults, etc., that should be avoided in sinking working shafts, cutting out stations, and driving extraction drifts, etc.[1] In short, a mining company should not deprive itself of the added value of the services its geologist may be able to render, by limiting his work to the study of the structure of the ore-body.

Before entering upon a discussion of the application of the methods of modern applied geology to the investigation of ore deposits, we must disabuse ourselves of the prevalent idea that the chief function of the geologist is to theorize regarding the genesis of the ore. Although it is true that we must draw deductions from our observations and thus theorize, to some extent, the conclusions that are of direct practical value are those that are the results of a scientific examination of the ore-body at hand, while the hypothetical discussions as to the magmatic or meteoric sources

[1] Linford and Milburn. "Geology applied to Mining." *Eng. and Min. Journ.*, Vol. XCI, pp. 664–667, 1911.

of the ore-forming solutions can hardly be of any assistance to the miner as a guide in the development of his ore-body. The scientific examination generally includes a field study of the region in which the mines are situated in order to locate those structural features that have affected the accumulation of the ore; the study of the present topography and the reconstruction of past topographies in order to determine how secondary processes such as oxidation, secondary sulphide precipitation, etc., have been at work redistributing the original metallic content of the ore; the detailed plotting in the vicinity of the ore-body, both at the surface and underground, of every fault, fissure, cleavage, stain, change in formation, rock alteration, and ore-body, and the critical study of the completed maps, in order to determine what structural features guided the formation of the ore. A detailed laboratory study of the mineralogy of the ores, the rock alteration and the character of the ore; that is whether or not it occurs as a fissure filling, a replacement of the country rock or a dissemination. Ore deposition is a complex process. Fissures may be formed and then be repeatedly reopened, and the value of the ore may be introduced at only one of the many periods of mineralization. Regardless of theoretical considerations, the determination that a fracturing of the vein material has taken place and that the deposition of a certain group of minerals gives to the ore its chief value, has proved in a number of cases to be an important criterion in judging the value of the ore deposit.

The first step in a detailed examination along these lines is the construction of a topographical map. For this purpose the plane table has advantages over any other instrument, and the methods developed by the United States Geological Survey are the standards for American practice.[1] Each operator, however, will develop or adopt short-cut methods of his own suitable for the conditions under which he is working, and it is not easy to point out just what are the advances of the last few years.

Every mining property, and I might almost add every decent mining prospect, should have a permanent and accurate triangulation system established, and with this as a base, the topographic, and later the geologic plane table map is made. The uses of a topographic mine map are discussed by Mr. Blackburn.[2] It is especially valuable to have the contours of the area on which an ore dump is to be deposited so that tonnage estimates can be made whenever desired.

The detailed surface geological map is constructed on a plane table,

[1] Gannet, Henry. "Manuel of Topographic Methods." Monograph XXII, and *Bulletin* 307, *U. S. Geol. Surv.*
Farrell, J. H. "Topographic Mine Mapping." *Eng. and Min. Journ.*, Vol. XCI, 1911, pp. 618–622, and "Practical Field Geology, Chapters I, II, and III.
[2] Blackburn, W. D. "Topographic Engineering." *Eng. and Min. Journ.*, Vol. LXXXVII, p. 997, 1909.

wherever there is a moderately open country. Here again the methods have been developed by the geologists of the national survey with refinements added by the consulting and mining geologists working in greater detail than attempted by the government or state surveys. The special methods involved include the instrumental location of points on outcrops in various ways, methods of note keeping, graphical methods for constructing geological sections, of solving fault problems, and of plotting geological structure on the mine plans. A large number of papers on various phases of this subject have appeared in the last few years, including a text-book on the solution of fault problems, a text-book on the general subject of geological mapping of mining prospects, and an excellent discussion of the methods of geological mapping under varying field conditions, from reconnaissance to detailed work, which is now running in the Economic Geology. The most important of these are listed below.[1]

As suggested above, the chief advance in the application of geology to the study of ore deposits is the plotting of all the data on geological maps and sections, the suspension of judgment and the avoidance of all snapshot opinion until the assembled data can be scrutinized, and the true significance of the phenomena observed during the examination is made clear. I remember of miners speaking of a famous old-time mine operator, stating that he had a wonderful memory, and that he knew what was revealed in every drift, and that he kept mental track of each one of the many drill holes he had put down. The work of a geological staff showed that he did not and could not carry all this in his mind, and that much of his exploration work was ill directed.

The scope of this article does not permit the interpretation of the data that may be compiled in such an examination as suggested above, and only a brief mention will be made of some of the problems that may present themselves.

Faults are common and often serious occurrences in mining. Any attempt to determine the direction and distance these dislocations have thereon the ore body by the miner's "nose for ore" or by the rules of thumb such as "Schmidt's rules" or "Vreeland's rules" or by any other method than that involving the plotting of all the data available and

[1] "Discussion of Methods of Geological Mapping." *Econ. Geol.*, Vol. VII, pp. 502–506, 778–783; Vol. VIII, pp. 67–96, 171–188, 264–297.
Farrell and Moses. "Practical Field Geology" (text-book).
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Ransome, F. L. "Plane Table in Detailed Geological Mapping." *Econ. Geol.*, Vol. VII, pp. 113–119.
Tolman, C. F. "Graphical Solution of Problems in Faulting" (text-book).
Wegermann, C. H. "Plane Table Method as Adapted to Geological Mapping." *Econ. Geol.*, Vol. VII, pp. 621–637.

the investigation of this data by the well-known methods of descriptive geometry, is not excusable today when every mining man is supposed to possess the rudiments of geology.

The fundamental importance of geological mapping is easily appreciated when for any reason whatever the deposit is found to be located in some one geological horizon or stratum. When the ore is further localized at the intersection of the stratum with some regular system of faulting or fracturing, the maps of the ore deposit show a regular and distinctive pattern (Fig. 2), and a rational system of exploration will be guided by the geological map of these features. When the ore deposits show preference to form along a system of faults having a common trend, or along certain dikes (Fig. 3) the location of these many assist planning exploration, although only a portion of the fissures or dikes may be accompanied by ore, or again only a portion of the ore-bodies may lie along the dikes. More interesting cases arise where we find say three systems of faults each having its own trend, one older than the ore, and therefore not dislocating the veins, or even assisting in the formation of ore shoots and bonanzas, by concentrating the ore solutions along their intersections with the veins, a system intermediate in age, in which the ore bodies

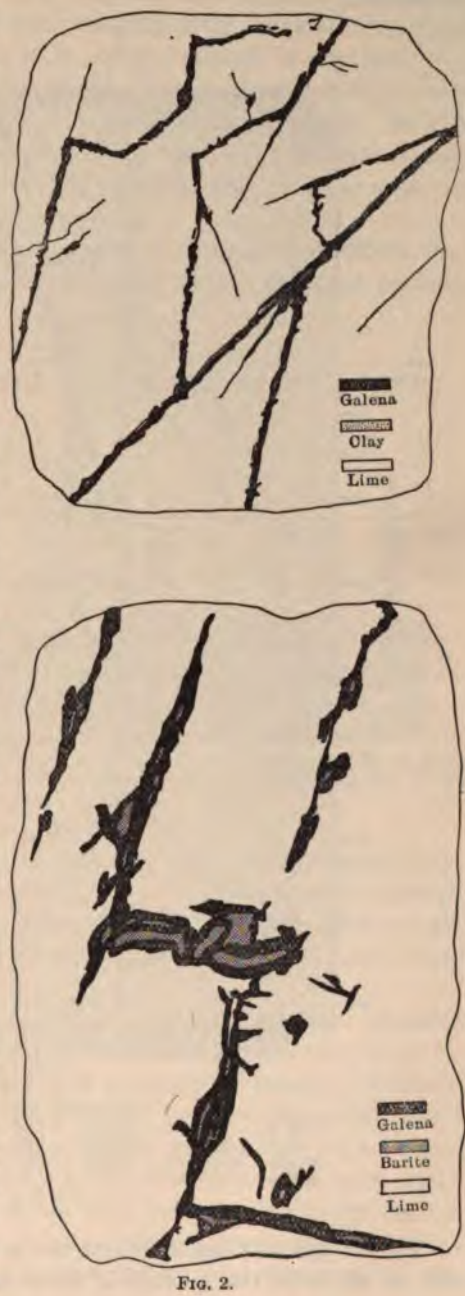
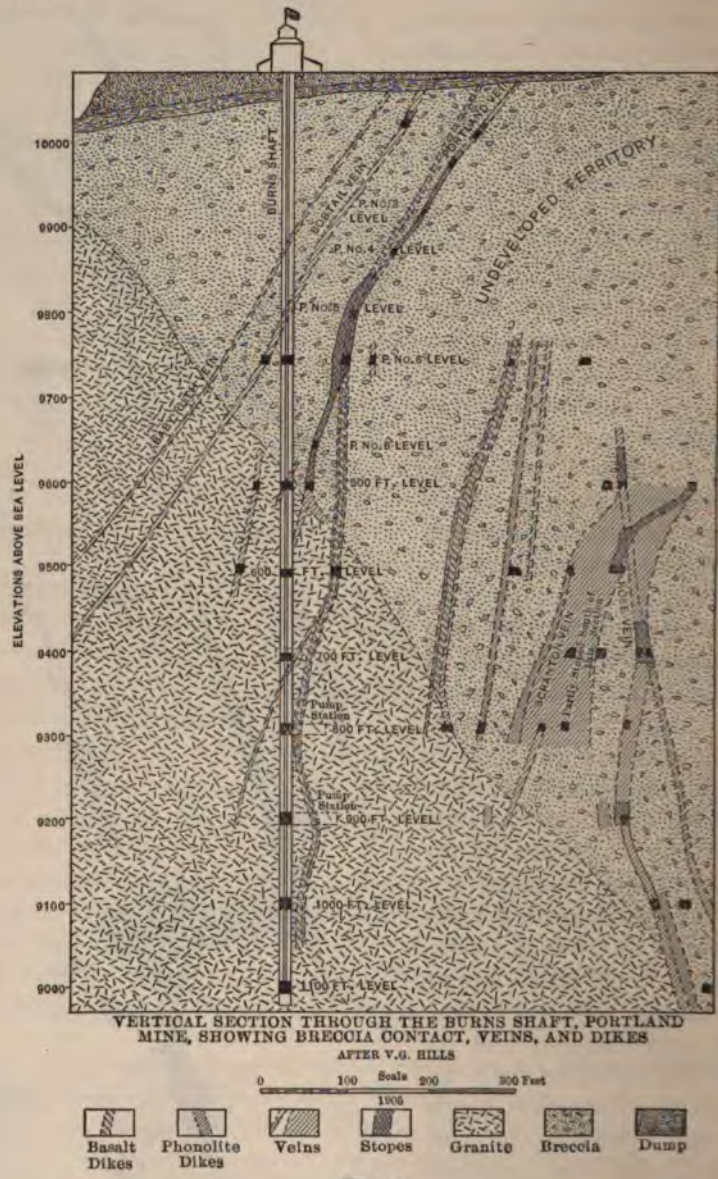



FIG. 2.

were the youngest system causing embarrassing dislocations of the ore-bodies.




VERTICAL SECTION THROUGH THE BURNS SHAFT, PORTLAND MINE, SHOWING BRECCIA CONTACT, VEINS, AND DIKES
AFTER V.G. HILLS

FIG. 3.

The details of vein structure are mapped and studied with the same care as those of the geological structure. A deposit is found to be of

the replacement type, and the geologist is on the keen outlook for the vagaries so commonly shown by such deposits, and interest is added to the search for the often insignificant and difficultly detected structural features that may guide the miner from one ore deposit to another.

The structure and the location of the precious content in a complex fissure vein is often best shown by a geological assay plan. In Fig. 4 it becomes evident that the gold content is located in the limonite streak, and all observations as to the extent and origin of this oxidized material becomes of immediate interest.

An examination of certain gold deposits of Canada has shown that the quartz gangue is of two kinds formed at widely different periods.

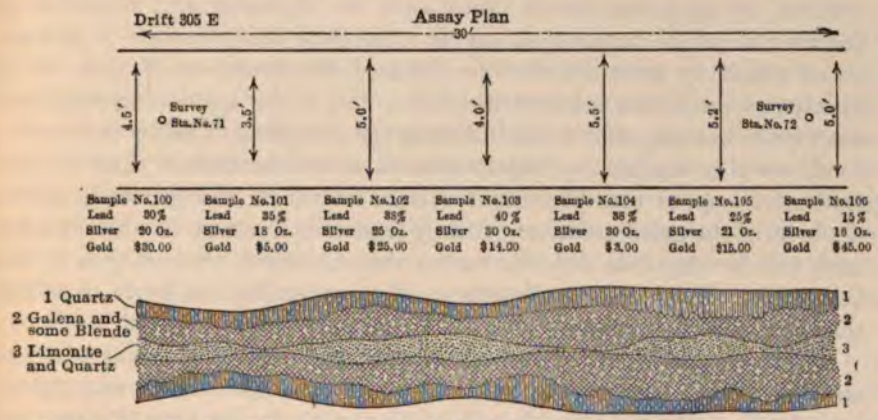



FIG. 4.—Upper Portion of Figure is a Map of a Drift, with Width of Ore at Points where the Samples were taken, indicated by the Double Arrow. Directly underneath is the corresponding Map of the orin structure.

The older is a dense massive quartz without value. Subsequent fracturing of the brittle quartz was healed by gold-bearing quartz veinlets. Whenever a criterion of this kind is found to be applicable to a certain mineralized region, it may be used effectively in determining which veins of the district are most promising.

*The Application of Geological Theory.*—Certain geological theories concerning the deposition of ores are so well founded that they may be considered established, while others fall in the realm of mere speculation. The correct application of the former, however, involves painstaking and accurate collection of data. Certain groups of gangue and ore minerals are known to continue to great depths under favorable conditions, without change, while other groups indicate with certainty a change from a valuable to a valueless combination at moderate depths. Careful investigation of the mineralogy and paragenesis of the ores leads to the

use not only of the ordinary petrographic microscope but also to the metallographic microscope,[1] and the number of important scientific contributions along these lines is increasing.

Among established theories, that of "secondary" or "downward sulphide enrichment" bears directly upon important classes of copper, silver, and gold deposits, and although the theory may seem simple, its successful application may lead one into many and varied lines of geological investigation, and the careless application of this theory has often led to false conclusions.

Quoting from a recent contribution:[2] "Since this enrichment is caused by the chemical action of water, trickling downward from the surface through fractured or porous rocks or concentrated in the stronger fissures, the geologist should investigate the character and structure of the rock which he suspects of having undergone this process. A decomposed porphyry or schist allows a diffused downward circulation which penetrates the entire mass of the rocks, and if the descending solutions are copper-bearing, and a precipitating agent is present below the water-level, we may confidently expect a more or less horizontal sheet of disseminated copper ore, the upper surface of which will generally be at the level of the ground-water. Strong fissures in a less permeable country rock will develop lode deposits rather than blankets, the strength of the fissure and the force of the downward flow governing the depth to which these deposits will extend." . . . . .

"Topography governs both downward percolation of water and the amount of rock exposed to leaching above the water-level, and therefore the investigator may be called upon to study not only the relation of the present topography to subsurface drainage, but to reconstruct past topographies, and to determine whether or not the rates of erosion and leaching have been so adjusted that a considerable thickness of copper-bearing rock has been worked over."

"The process involves the oxidation and solution of the sulphides above the water-level as well as the deposition of the sulphides below that level, and therefore it is necessary to examine the specking, staining, etc., of the surface rock in order to determine whether or not such specks are the remains of metallic sulphides or whether they are the residues

[1] Bastin, E. S. "Metasomatism in Downward Sulphide Enrichment." *Econ. Geol.*, Vol. VIII, pp. 51–64, 1913.
Campbell, Wm. "The Microscopic Examination of Opaque Minerals." *Econ. Geol.*, Vol. I, pp. 751–763.
Finlayson, A. M. "The Pyritic Deposits of Huelva, Spain," paragraph on microstructure. *Econ. Geol.*, Vol. V, pp. 416–420.
Laney, F. B. "The Relation of Bornite, and Chalcocite in the Copper Ores of Virgilina District." *Econ. Geol.*, Vol. VI, pp. 399–412, 1911.
Singewald, J. T. "The Microstructure of Titaniferous Magnetite." *Econ. Geol.*, Vol. VIII, pp. 207–216.

[2] Tolman, C. F. "Secondary Sulphide Enrichment of Ores." *Min. and Sci. Press*, Jan. 9, 18 and 25, 1913.

of iron-bearing silicates such as biotite, hornblende, etc., the leaching of which could not give rise to copper enrichments."

Geologic, topographic, and microscopic work will generally be involved in such an investigation.

It is established that many and varied ore deposits are developed in the "metallic aureole" around and in the outer margin of certain intrusives, especially of granitic character, and yet generalizations from this important theorem, unless aided by a geologic examination, are difficult to summarize. I note here only the suggestion that a mineral-bearing quartz vein located deep within the mass of a granite intrusive will probably turn out to be only a lenticular bunch of ore, while some favored few ore deposits in or near the roof of the batholith may go down to great depths.

This leads to the question: To what depths will a vein extend? This inquiry has given rise to much discussion,[1] some of which at least has been of little profit. After all structural details of the deposit have been investigated and their import studied, and the type of the deposit successfully determined, and the mineralogy of the ores given due attention, in order to find out whether or not they were formed under deep seated or superficial conditions, then we may investigate the thickness of over-lying rock which has been removed by erosion, in order to determine if possible whether we have to do with the roots of a vein or with one that has suffered small loss from the agencies of erosion.

Every examination of a mine is an original investigation, and the particular problems presented may involve any of the numerous methods of geologic research or may call for the development of new methods. For this reason this article is suggestive rather than a summary of actual methods.

[1] Emmons, W. H. "A Genetic Classification of Minerals." *Econ. Geol.*, Vol. 3, pp. 611–627, 1900.
Lindgren, W. "The Relation of Ore Deposition to Physicial Conditions." *Econ. Geol.*, Vol. II, pp. 105–127, 1907.
Lindgren, W. "Ore Deposition and Deep Mining." *Min. and Sci. Press*, Vol. XCII, p. 41, 1906.
Rickard, T. A. "The Persistence of Ore in Depths." *Min. and Sci. Press*, Vol. CV, pp. 232–238, 264–268.
"Discussion of Persistence of Ore in Depth." *Min. and Sci. Press*, Vol. CV, pp. 311, 337, 407, 459, 634, 668, 802.

# PROGRESS IN ORE DRESSING AND COAL WASHING IN 1912

By Robert H. Richards and Charles E. Locke.

## General

The progress in the use of flotation in ore dressing during the past year is most noteworthy. The history of all new processes shows that their development is slow and flotation is no exception. Although it has been in use for several years in other parts of the world, only now America is beginning to take it up and Canada is in the lead of the United States. The Elmore process has recently been applied to the zinc milling of British Columbia and an Elmore plant is about to be installed at the Eustis pyrite mine in Quebec.

Other lines of progress have been in the increased use of hand sorting, in the study of crushing machinery, especially that for fine crushing, and in the work on the slime problem. The Hardinge mill has been found to be adapted to many of the problems of fine crushing in concentration and its use has shown a marked increase. The slime problem has been attacked in three ways: in the use of proper crushing machinery to make the minimum amount of slimes; in the efficient treatment of slimes, when made, by canvas tables or other forms of slime tables; and in the possibility of the use of flotation processes in dealing with slimes.

The step method of concentration where material first receives a roughing treatment on a machine with high capacity which is followed by a careful finishing treatment of the rough concentrates on a machine having a lower capacity, is receiving merited attention. As a rule, however, the millmen have not yet learned the advantage of coupling two machines together, one of which makes clean tailings and sends concentrates to be cleaned on a second which makes high-grade concentrates and sends rich tailings back to the first. The advantage of sending material as soon as possible to its proper department is also being recognized, for example, slimes should be removed from the ore early in the process and sent to the slime department. Amalgamation in the case of gold ores appears to be on the decrease owing to the progress in cyanide methods.

## Crushing and Grinding

*Rock Breakers.*—Comparison of gyratory and jaw breakers has been made in Richards Ore Dressing, Vol. I.[1] Additional points based on the experience of three engineers, each having used both styles of breakers are as follows: For large capacities the gyratory has lower capital cost for actual tonnage handled; ordinary renewals are not greatly dissimilar; extraordinary repairs on the gyratory may offset largely, if not entirely, its other advantages.

An interesting method of balancing jaw breakers has been discovered by O. P. Hood.[2]

The rock-breaker practice at Kalgoorlie[3] is to place the breakers in a separate building on solid foundations and use conveyor belts instead of setting them on top of the ore bins where they shake the building, are not easily repaired, and do not allow easy distribution of the ore. Jaw breakers have the Bigelow patent safety toggle made in two parts which are flat and overlap being held together by ten steel rivets with a total shearing strain of 360 tons. On gyratory breakers, adjustment of the No. 7 1/2 Gates, Type K, is made at the top instead of at the step, the spindle and head being suspended instead of supported. Stage crushing is preferred by the larger mills as shown by the table.

BREAKERS AT KALGOORLIE.

| Mine. | Breakers. | Tons Crushed per day. (*b*) | How driven. | Cost per Ton cents. (*c*) |
|---|---|---|---|---|
| Associated | 1 Gates 7/2 K | 360 | 80 h.p. motor | 10 |
| Associated Northern.... | 1 Gates No. 5 | 70–120 | Engine | 10 |
| Boulder (*a*) | 6 Hadfield No. 5 and R. & S. 7 1/2 and 5 | 600 | Motors | 8 |
| Hainault | 3 Fraser & Chalmers 20×10 in. and 16×9 1/2 in. | 230 | Motors | 10 |
| Horseshoe | 3 Gates 7 1/2 and 5 | 800 | Motors | ..... |
| Ivanhoe | 3 Gates 7 1/2 and 5 | 650 | Engine | 6 |
| Kalgurli | 3 Fraser & Chalmers 30×12 and 15×9 in. | 360 | Engine | 8 |
| Lake View | 2 Bigelow 30×12 in. | 600 | Motors | ..... |
| Perseverance | 2 Gates No. 3 1 Hadfield 30 × 18 in. | 700 | Motors | 11 |
| Oroya Links | 2 Bigelow 30×12 in. | 360 | Motors | 10 |
| South Kalgurli | 1 Bigelow 30×12 in. | 330 | Motors | 9 |

(*a*) The Boulder has also 3 Gates type H for crushing to about 1 inch for Griffin mills. (*b*) Deduct 20 per cent. for fines. (*c*) Includes transport to mill bins, about 4 cents per ton.

Jaws last up to 180 days. The No. 5 Gates liners will crush 100,000 tons. The No. 7 1/2 liners will run fully 270 days. Manganese steel liners are entirely satisfactory but not cast iron chilled for about 1/2-in. depth. It is not necessary to fill in behind the jaws with metal, but new mantles or concaves are run with zinc. Wheel eccentrics of good metal

[1] *Min. and Sci. Press*, Vol. CIV (1912), p. 215.
[2] Lake Superior Mining Institute, Vol. XVII (1912), p. 162; *Met. and Chem. Eng.*, Vol. X (1912), p. 681.
[3] M. W. von Bernewitz, *Min. and Sci. Press*, Vol. CV (1912), p. 469.

have lasted as long as 18 months on a No. 5 Gates and 9 months on a No. 7 1/2. Plenty of good lubricants is essential.

*Rolls.*—Past development of rolls has reached its highest state in the field of medium crushing down to 1/2 or 1/4-in. size. They are used almost universally in concentrating mills for this work and are made as large as 54 in. diameter, and 28 in. face. For fine crushing down to 20 or 30 mesh, rolls have to compete with other types of grinders, in spite of the well-known advantage of rolls that they produce a granular product. This is on account of the irregular wear of the roll faces, and the necessity of truing them up at frequent intervals.

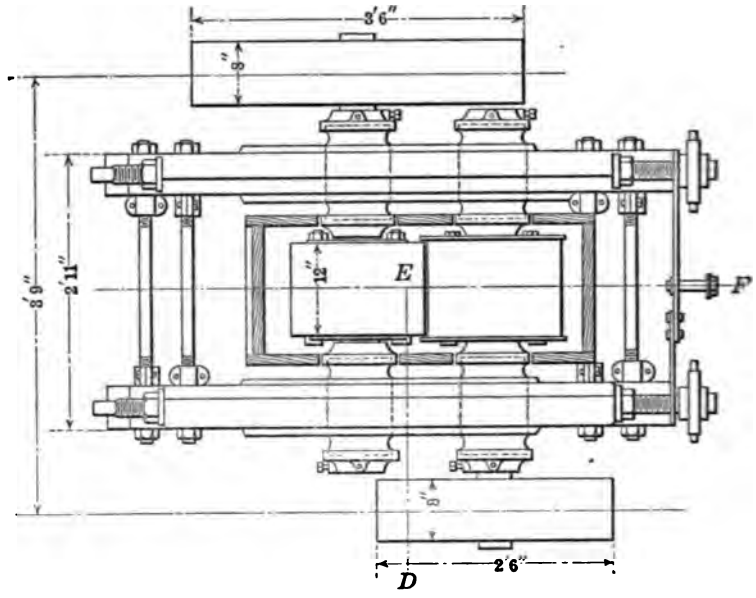



FIG. 1.—Plan of Frazee rolls below roll housing.

Edison has avoided this difficulty by using the principle of "choke crushing" under very high pressure, but at a sacrifice of granularity in the product.

The Frazee rolls[1] are reported to accomplish the same result by making use of the old method of having one roll a little longer than the other and by having flanges at the ends of this long roll between which the shorter roll runs with a slight clearance as shown in Fig. 1. A pair of 24-in. shells with 14.5-in. face weighing 1776 lb. when new wore down to a thickness of only 5/8 in. at the edges and to a weight of 438 lb. The only

[1] C. Q. Payne, *A. I. M. E., Bulletin* No. 66, June, 1912, pp. 577, 763; *Iron Age*, Vol. LXXXIX (1912), p. 655; *Met. and Chem. Eng.*, Vol. X (1912), p. 170; *Eng. Mag.*, Vol. XLII (1912), p. 801; *Eng. and Min. Journ.*, Vol. XCIII (1912), p. 370.

machine work required is a partial removal of the flanges on the longer roll shell as the wear of the shells progresses. The flanges are 1/8 or 1/4 in. high at the start. Steel roll shells are preferable to chilled iron, owing to the possibility of breakage of flanges on the latter.

Fine crushing rolls recently installed in the Miami and other mills have an automatic side adjustment to keep the roll shells smooth and avoid corrugations and flanging at the ends.[1]

*Pneumatic Stamps.*—Instead of gravity stamps and tube mills the new Mountain Queen mill in Western Australia has installed two Holman pneumatic stamps followed by two 5-ft. grinding pans.[2] The Holman stamp follows the general type of air cushion stamps having a cylinder which is given a vertical reciprocating motion from a crank. Inside the cylinder is the piston which is actuated by the cylinder through the medium of the air cushion at each end. There are small air holes in the walls of the cylinder to control the relative position of the piston inside the cylinder. The Holman stamp has four rows of these holes to allow for wear of shoes and dies. At the start the top and third row are open and the second and bottom rows are plugged. As the shoes and dies wear the second and bottom rows are opened, and the two other rows plugged, thus allowing the blow to be struck at a lower level. The cylinder is 9.5 in. diameter and the stroke is 12 in. Fed with material through a 2 1/4-in. grizzly and using a 12-mesh screen the two stamps together crush 160 tons per day using 15 to 17 h.p. per stamp and 123 blows per minute on soft ore or 20 to 25 h.p. and 135 blows on hard ore. The mortar has three screen openings and the water required is six times the weight of the ore. In seven months the two stamps crushed 24,892 tons and the wear of shoes was 0.248 lb. per ton and of dies 0.199 lb. These two stamps do the work of fifteen gravity stamps.

*Gravity Stamps.*—With reference to the tests of Nissen Stamps on the Rand (MINERAL INDUSTRY, Vol. XX, p. 359) the original computations were based on the assumption that the weight of stamps represented horse-power consumed. H. Stadler[3] has recomputed the crushing efficiencies by figuring the mechanical value of the sizing tests and by figuring energy in foot-pounds per second. His figures are shown in the table.

The table shows an increase in efficiency for the Nissen stamps varying from 23.5 per cent. up to 47.5 per cent. This increase may be explained as follows: Circular screen allows more rapid discharge and leaves a residue containing a larger proportion of free interstices. Rapid

[1] S. W. Traylor, *Met. and Chem. Eng.*, Vol. X (1912), p. 378.

[2] M. W. von Bernewitz, *Min. and Sci. Press*, Vol. CV (1912), p. 148. W. R. Degenhardt, *Monthly Journal Chamber of Mines of Western Australia*, Aug., 1912, p. 187; *Min. Mag.*, Vol. VII (1912), p. 379. *Met. and Chem. Eng.*, Vol. X (1912), p. 815; *Journal Chem., Met. and Min. Soc. of South Africa*, Vol. XIII (1912), p. 172; *Eng. and Min. Journ.*, Vol. XCIV (1912), p. 883.

[3] *Min. and Sci. Press*, Vol. CIV (1912), p. 274; *Eng. and Min. Journ.*, Vol. XCIII (1912), p. 354; From *South Af. Min. Journ.*, Dec. 2, 1911.

| | Tyler Ton Cap, 9 mesh. 0.205 by 0.536 in. | | | | 9 mesh. 0.277 in. square. | | 3/8 in. square mesh, 0.375 in. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nissen Stamp. | City Deep. | Nissen Stamp. | City Deep. | Nissen Stamp. | City Deep. | Nissen Stamp. | City Deep. | Nissen Stamp. | City Deep. |
| Foot-pounds per second per stamp | 23.49 | 21.99 | 23.43 | 21.94 | 24.23 | 20.95 | 28.11 | 22.54 | 24.21 | 20.92 |
| [1]Power consumption per stamp, horse-power | 5.34 | 5.00 | 5.33 | 4.98 | 5.51 | 4.76 | 6.39 | 5.12 | 5.50 | 4.75 |
| Duty per 24 hours, per stamp, tons | 24.47 | 18.26 | 23.73 | 19.90 | 29.81 | 20.95 | 36.69 | 22.72 | 27.74 | 24.34 |
| Duty (theoretical) | (24.50) | (23.00) | (24.50) | (23.00) | (24.50) | (21.00) | ..... | (24.00) | (26.00) | (22.50) |
| Mechanical value of pulp, Energy Units | 17.25 | 17.44 | 17.31 | 17.52 | 16.97 | 16.88 | 16.88 | 16.57 | 16.28 | 16.31 |
| [2]Relative mechanical efficiency per horse-power | 79.00 | 63.69 | 90.00 | 70.00 | 91.80 | 74.30 | 108.40 | 73.50 | 111.70 | 83.60 |
| Increase in efficiency | 24.4 % | | 28.6 % | | 23.5 % | | 47.5 % | | 33.6 % | |

[1] $\frac{\text{Foot-pounds per second} + 25 \text{ per cent.}}{550} = \text{horse-power.}$

[2] Relative mechanical efficiency $= \frac{\text{duty (tons per 25 hours) by mechanical value.}}{\text{horse-power}}$

discharge means less attrition and abrasion and consequent loss of energy. The dies are more firmly placed in a single unit mortar and hence the blows are more solid. The depth of the bed can also be better regulated to give maximum crushing effect and avoid loss of energy in causing deformation of the ore particles without reaching their breaking point.

Continuing the discussion of the breakage of cam shafts, Mr. A. Del Mar[1] states that the chief cause is faulty alignment and suggests that the length of the cam shaft be limited to five stamps since experience has shown that such a shaft is more easily kept in line and therefore seldom broken. To avoid vibration and maintain alignment strong concrete frames are the best and horizontal pull of the belt is prevented by placing the driving shaft in a tunnel in the concrete mortar block vertically beneath the cam shaft. This tunnel is made large enough to allow the passage of a man. The hold down bolts for the mortar also extend down into this tunnel and are anchored in such a way that they may be easily replaced if broken.

The steel and concrete stamp frame of the new City Deep mill in South Africa is reported not to be entirely satisfactory. The concrete cracked owing to vibration. The long heads gave trouble because the adhesion between them and the stems, despite the degree of taper given was often insufficient. Also the shanks of the shoes showed a tendency to break off.[2]

The stamp mill practice of the

[1] *Min. and Sci. Press*, Vol. CIV (1912), pp. 113, 176.
[2] *Eng. and Min. Journ.*, Vol. XCIII (1912), p. 795.

McKinley-Darragh-Savage silver mill at Cobalt[1] makes use of the by-pass system whereby all material finer than 1/8 in. is separated from the stamp feed and is given a separate treatment by jigs and tables. The stamps have a screen with slots 0.375×0.187 in. The coarse stamp pulp together with the coarse tailings from the treatment of original fines are reground in a Hardinge mill. The separate treatment of fines is warranted by the character of the ore. The nickel-cobalt minerals are friable and tend to form fines, while the coarser material in the stamp product is relatively lean in these minerals although it may contain its proportion of the native silver of the ore.

*Huntington Mill.*—The commonly expressed claim that the Huntington mill is preeminently suited to the crushing of soft ores is exemplified by the practice at Kalgoorlie.[2] Details of the practice are given in the tables.

OPERATION OF HUNTINGTON MILLS, KALGOORLIE.

| Mine | Number Used.[1] | Revolutions per Minute. | Horse-Power. | Drive. | Tons per Mill per Day. |
|---|---|---|---|---|---|
| Golden Dream | 1 | 68 to 71 | 10 | Crossley gas engine | 54 |
| Cassidy Hill | 1 | 70 | 6 | A. E. G. motor | 50 |
| Lone Hand | 1 | 68 | 6 | A. E. G. motor | 80 |
| Hannan's Consols | 2 | 74 | 6 | A. E. G. motor | 30 to 45 |
| Adeline | 3 | 70 | 6 | Horneby gas engine | 30 |
| Lomassney & Co. | 1 | 74 | 6 | Crossley gas engine | 48 |
| Lake View South | 1 | 70 | 8 to 12 | Tangye gas engine | 50 to 70 |

| Class of Ore. | Gallons Water per Ton of Ore. | Life of Die Ring, Days. | Life of Roller, Days. | Plates. | Amalgamation. |
|---|---|---|---|---|---|
| Average oxide | 250 | 240 | 120 | 12×5 ft. | 30% inside |
| Fair per cent. quartz | 200 | 180 | 70 | 12×5 ft. | Varies |
| Kaolin | 250 | 210 | 120 | (2) 5 ft. | Varies |
| Fairly hard | 180 | 160 | 60 | (2) 5 ft. | Varies |
| Mixed | 200 | 150 | 120 | (2) 5 ft. | 25 to 60% |
| Iron and quartz | ..... | ..... | ..... | (2) 5 ft. | 20 to 50% |
| Iron and quartz | 200 | 150 to 270 | 180 to 270. | 12×5 ft. | Low |

COSTS IN CENTS PER LONG TON.

| Water. | Power. | Labor. | General. | Total. |
|---|---|---|---|---|
| 23 | 5 | 30 | 8 | 66 |
| ..... | ..... | ..... | ..... | 80 |
| 18 | 8 | 12 | 2 | 40 |
| 8 | ..... | ..... | ..... | 72 |
| 18 | 3 | ..... | ..... | ..... |
| 8 | 8 | ..... | ..... | ..... |
| ..... | 8 | ..... | ..... | ..... |

[1] J. G. Mueller, *Eng. and Min. Journ.*, Vol. XCIV (1912), p. 408.
[2] M. W. von Bernewitz, *Min. and Sci. Press*, Vol. XC (1912), p. 618.

*Chile Mills.*—In fine grinding the adherents to each system still continue to advance their arguments in favor of their own method. E. H. Webster[2] points to the development of the Chile mill in Mexico where at La Union mill a Chile mill is fed with ore of average hardness from a breaker set at 1 1/2 in., and in one operation reduces it to a product 80 per cent. of which will pass 200 mesh with the high mechanical efficiency of 46.13 per cent. This high efficiency together with the simplicity of single-stage grinding in a machine so simple and reliable as the Chile mill form strong arguments for it against multiple-stage crushing in other types of machines. The Mexican type of mill has a pan of comparatively small diameter to take advantage of the rubbing effect or twisting motion which is desirable for sliming and which is increased as the radius of the circular path of the rollers in the pan is shortened. This same effect in a broader pan requires thicker and heavier rollers. An improvement on the Mexican mill would be a direct drive for the vertical shaft either by chain or rope. For hard rock an increase in the diameter and weight of the rollers would be necessary.

In analyzing the figures in the papers by Bayldon and Empson of last year on Chile mills the following points are brought out.[3]

A Russian Chile mill grinding 16 tons daily and running 12 revolutions per minute had its capacity increased 62 per cent. by increasing the speed 14 per cent. The mechanical efficiency was increased from 50 per cent. to 66 per cent., and the mechanical energy units were 25.16 and 24.33 respectively. This leads to the conclusion that there is a critical speed at which the mill works most advantageously. The size of feed also affects this critical speed, the output and efficiency both being greater on 1.5-in. feed than on 3-mesh feed. This is shown in the table which gives results of high-speed Evans-Waddell Chile mills at Guerrero mill, Pachuca, and high-speed Akron mills in Rhodesia.

| Mill. | Feed. | Tons per Day. | Horse-power Used. | Net Mechanical Units Represented by Discharge. | Lb. Ore through Finest Mesh per h.p. per Minute. | Mechanical Efficiency of Mill. |
|---|---|---|---|---|---|---|
| Evans | Fine | 38 | 35 | 7.47 | 0.47 through 200 | 8.1 |
| Evans | Fine | 126 | 50 | 6.73 | 0.92 through 200 | 17.0 |
| Akron | Coarse | 118 | 25 | 12.64 | 3.20 through 150 | 60.0 |

The field of the Chile mill lies in replacing the stamp tube-mill combination. It is not believed that the Chile mill can economically replace stamps in coarse crushing preparatory to tube milling. Efficiencies

[1] All mills are 5 ft. in diameter.
[2] *Eng. and Min. Journ.*, Vol. XCIII (1912), p. 393.
[3] G. A. Denny, *Informes y Memorias del Instituto Mexicano de Minas y Metalurgia*, Vol. III (1912), p. 11. *Canadian Min. Journ.*, Vol. XXIII (1912), p. 832.

of the stamp tube-mill combination are given in following table which may be compared with the previous table.

| | Stamps. | | | | | Tube Mill. | | | Combination. | |
|---|---|---|---|---|---|---|---|---|---|---|
| Practice. | Weight Stamps Pounds. | Mesh Used. | H.p. per Stamp. | Tons per Stamp per Day. | Mech. Eff. | Tons per Day per Mill. | H.p. per Mill. | Mechanical Efficiency. | Mechanical Efficiency. | Pounds through 200 Mesh per h.p. per Min. |
| United States.. | 1050 | 20 | 2.5 | 3.5 | 34.5 | 52 | 42.5 | 6.5 | 23.5 | 0.90 |
| South Africa... | 1600 | 3 | 4.5 | 20.03 | 78.3 | 160 | 95.0 | 20.6 | 37.3 | 1.44 |

The next table gives efficiencies of the Pachuca type of Chile mill doing fine grinding in Mexico.

| Mill. | Maximum Feed, Inches. | Tons Crushed per Day. | Horse-power | Mechanical Efficiency. | Pounds through 200 Mesh per Horse-power per Minute. |
|---|---|---|---|---|---|
| La Union..... | 1.5 | 16.53 | 13 | 34.60 | 1.41 |
| La Union..... | 1.5 | 22.04 | 13 | 46.10 | 1.86 |
| Santa Elena..... | 2.0 | 27.55 | 15 | 49.09 | 1.39 |
| A..... | 2.0 | 18.00 | 11 | 27.50 | 0.84 |
| B..... | 1.5 | 22.50 | 17 | 21.40 | 0.60 |
| Purisima Grande..... | 1.5 | 24.00 | 17 | 28.80 | 0.92 |

The next table gives a comparison of high-speed Chile mills with fine-feed and low-speed mills with coarse feed and shows how the former are unsuited for their work.

| Dry Ore Fed in Pounds per Minute. | Horse-power Used. | Energy Units in Feed. | Energy Units Developed by Mill per Ton. | Mechanical Efficiency. | Pounds per Horse-power through 200 Mesh per Minute. |
|---|---|---|---|---|---|
| Mills taking feed from Callow screens which are supplied by a stamp mill crushing through coarse screen. | | | | | |
| 48.5 | 35.0 | 16.21 | 7.47 | 8.10 | 0.42 |
| 123.2 | 41.0 | 16.17 | 7.47 | 16.20 | 0.85 |
| 154.0 | 48.0 | 16.07 | 7.62 | 17.60 | 0.92 |
| 136.4 | 44.0 | 16.03 | 7.68 | 17.10 | 0.92 |
| 176.0 | 50.0 | 17.07 | 6.73 | 17.00 | 0.92 |
| 74.8 | 35.0 | 15.93 | 7.38 | 11.70 | 0.64 |
| 88.0 | 38.0 | 16.74 | 6.97 | 11.60 | 0.57 |
| Fed direct from breakers and grinding through 100 mesh. | | | | | |
| 54.2 | 16.27 | ..... | 25.63 | 63.09 | 2.36 |
| 54.2 | 16.27 | ..... | 26.00 | 63.97 | 2.60 |

The following costs per ton of three types of machines at the Goldfield Consolidated mill show the advantage of the Chile mill:

| | Labor. | Supplies, Repairs, Up-keep. | Power. | Total. | Per Cent. of Time Lost Owing to Machine. |
|---|---|---|---|---|---|
| Stamps through 4 mesh.. | $0.039 | $0.041 | $0.054 | $0.134 | 0.46 |
| Tube mills..... | 0.014 | 0.065 | 0.087 | 0.166 | ..... |
| Chile mills on fine feed... | 0.018 | 0.041 | 0.047 | 0.106 | 0.17 |

The most efficient Chile mill should have a groove in the center of the rollers, with a pan as narrow as possible consistent with the requirements that no coarse material be discharged through the screen, and an arrangement for adding compensating weights as the tires wear. The rollers should be large enough in diameter to afford a satisfactory angle of nip.

In the Black Hills district where it has been customary to use stamps for crushing gold ores, it is interesting to note that the new Minnesota mill uses rolls and Chile mills.[1]

*Fine Grinding.*—The combination of gravity stamps and tube mills seems to be the most favored; but there is a promising field of research to compare the various systems of fine grinding now in use, viz: rolls, fast Chile mills and tube mills; stamps, fast Chile Mills and tube mills; slow Chile mills either with or without tube mills; stamps and tube mills; stamps and grinding pans.

It is held by some engineers that stamps may be economically replaced by ball mills when doing coarse crushing work.[2]

The new Mexican mill for Comstock ores uses stamps crushing through 4 mesh followed by Chile mills with 24 mesh "ton cap" screens (0.018-in. openings). The Chile mill product containing 43 per cent. finer than 200 mesh is classified and the sand (17 per cent. below 200 mesh) is ground in tube mill giving a product with 51 per cent. finer than 200 mesh.[3]

Even in South Africa where stamps and tube mills are almost universal, there exists a difference of opinion as to their advantage, and their opponents point to one of the South African mills which uses single-stage crushing by stamps and obtains a higher efficiency than mills using stamps and tube mills. In entering the realm of coarse crushing the stamp appears to have left its legitimate field to do work that can be done better by rolls. This view is held by J. A. Yule[4] who states that although they have the advantages of simplicity and reliability, they require a large capital expenditure, have a high running cost, are wasteful of power and demand an excessive amount of water. He makes the radical prophecy

[1] J. Simmons, *Min. and Eng. World*, Vol. XXXVII (1912), p. 813.
[2] M. W. von Bernewitz, *Min. Mag.*, Vol. VI (1912), p. 59.
[3] W. Symmes, *Eng. and Min. Journ.*, Vol. XCIV (1912), p. 701.
[4] *South African Min. Journ.*, July 20, 1912. *Met. and Chem. Eng.*, Vol. X (1912), p. 768. *Min. Mag.*, Vol. VII (1912), pp. 186, 221.

that South Africa has seen the last installation of the stamp tube-mill combination.

One engineer[1] in discussing the development of fine-grinding proposes to use stamps and two tube mills in series.

A comparison of grinding pans and tube mill at the Homestake mill will be found later on in this article under Amalgamation.

*Tube Mills.*—A cylindrical tube mill was first brought forward as a sliming machine in the gold cyanide mill. The Hardinge[2] conical pebble mill was originally designed for the same purpose, but its lines were calculated to make it more efficient by adjusting its work along the side of step crushing. In it the variation in diameter results in a natural adjustment of the size of the pebbles, of the peripheral speed, and of the centrifugal force so that at the large or feed end the coarse pebbles are engaged upon the coarser particles of ore while at the smaller or discharge end are found only small pebbles which are engaged in the finishing work on the fine particles of ore. Any fine particle in the feed makes its way rapidly to the discharge end without receiving unnecessary comminution. This principle of granulation together with the simplicity of the machine has led to an extension of the field of the Hardinge mill and it has recently been installed in several ore dressing plants where granulating rather than sliming is desired. The Utah-Apex, the Calumet and Hecla, the Miami and the Federal are among those who have made the change and who report very satisfactory results. The Calumet and Hecla and the Miami mills formerly used Chile mills while the Federal used Huntington mills. At the Miami mill the power consumption of the Hardinge mill is somewhat less, the repairs and maintenance are very much less, and the percentage of 200-mesh slime made is considerably lower than that produced by Chile mills. The accompanying table shows the work of 8-foot Hardinge mills treating material between 5 and 1 mm., in size.

| | Calumet and Hecla Mining Co. | Federal Mining and Smelting Co. | Miami Copper Co. |
|---|---|---|---|
| On 40 mesh, per cent. | 2.0 | 4.0 | 16.0 |
| Through 40 on 60 mesh, per cent. | 2.1 | 7.5 | 15.5 |
| Through 60 on 80 mesh, per cent. | 6.5 | 7.0 | 8.9 |
| Through 80 on 100 mesh, per cent. | 6.0 | 10.5 | 7.7 |
| Through 100 on 200 mesh, per cent. | 43.0 | 18.0 | 13.8 |
| Through 200 mesh, per cent. | 40.8 | 53.0 | 38.1 |
| Tons per 24 hours | 45.0 | 99.4 | 180.0 |

In dry grinding the most efficient peripheral speed is between 625 and 725 ft. per minute of largest diameter. The amount of water for fine or slime grinding should be about 40 per cent. of water to 60 per cent. of

[1] H. Hanson, *Canadian Min. Institute*, Vol. XXV (1912), p. 168.
[2] H. W. Hardinge, *Canadian Min. Institute*, Vol. XXV (1912), p. 129. *Min. and Eng. World*, Vol. XXXVII (1912), p. 487.

solids by weight. For coarser grinding more water is necessary. The following table shows the effect of varying the amount of water and inclination of a mill fed with ore of the same size and at the same rate.

| | Feed. | Discharge, First Test. | Discharge, Second Test. | Discharge, Third Test. |
|---|---|---|---|---|
| On 8 mesh | 16.7 | | | |
| Through 8 on 20 mesh | 51.1 | 4.8 | | |
| Through 20 on 40 mesh | 13.9 | 9.8 | 1.3 | |
| Through 40 on 60 mesh | 6.8 | 22.8 | 8.0 | 1.4 |
| Through 60 on 80 mesh | 4.4 | 22.3 | 27.5 | 10.0 |
| Through 80 on 100 mesh | 3.0 | 0.9 | 2.5 | 2.0 |
| Through 100 mesh | 7.0 | 39.0 | 60.0 | 87.0 |

The question of the relative efficiency of pebbles of various sizes in tube milling is an open one although it is generally recognized that ball and tube mills are more efficient when they contain mixed sizes of balls and pebbles. A. W. Allen[1] has pointed out while the large pebbles have the advantage of greater energy of impact per pebble, on the other hand, the small pebbles have the advantage of a greater number of impacts per unit weisht of pebbles.

Practical experience is continually adding to our knowledge of the best conditions for tube milling. The proper dimensions and speed of the mill and other conditions are being carefully studied. These studies have led Mr. F. C. Brown[2] to the following conclusions:

The diameter of the mill should be governed by the fineness of the feed. For stamp pulp through 6 mesh a diameter of 4 ft. is suitable, and for finer feed a smaller diameter down to the point where the mill becomes too small to reline and repair easily. A 5 ft. mill is large enough to treat feed 1/3 in. in diameter.

The length of the mill governs the fineness of the product; a short mill for a granular product and a longer mill for sliming. For grinding 6-mesh stamp pulp through 200 mesh a mill 4 ft. in diameter and 16 ft. long. At Broken Hill a 4×13 ft. mill grinds tailings that are all through 10 mesh and have 60 per cent. on 40 mesh. The product has about 10 per cent. on 40 mesh. Two short mills in tandem with a classifying device between them will do better work than one mill of a length equal to the combined length of the two mills.

Speed is determined by the diameter and by the kind of lining. It should be reduced as the liners wear. A 4-ft. mill with smooth liners is usually run at 32 revolutions per minute and a 5-ft. mill at 27 revolutions per minute. If these mills are lined with metal plates the net inside diameters are 3 ft. 10 in. and 4 ft. 10 in., giving peripheral speeds of 382

[1] *Min. and Sci. Press*, Vol. CIV (1912), p. 19.
[2] *Min. and Sci. Press*, Vol. CIV (1912), p. 206; *Min. and Eng. World*, Vol. XXXVI (1912,) p. 665; *Am. Met. Soc.*, Vol. I, (1912), p. 111.

and 407 ft. per minute respectively. Ball gives 37 revolutions per minute or a peripheral speed of 333 ft. per minute as the most efficient speed for a mill 2 ft. 10 in. in diameter inside the liners. The standard tube mill in the Transvaal has a diameter of 5 ft. 6 in. inside the shell, or 4 ft. 6 in. net when newly lined with silex blocks. It runs at 31 to 32 revolutions per minute, and has a peripheral speed of 445 ft. per minute at the start increasing to 494 ft. per minute when the lining is worn out. These speeds are probably too high for the best work.

The size of the pebbles should be adjusted to the diameter of the mill and the size of the feed. Pebbles ranging from 2 to 3 in. in diameter answer for the usual grinding of pulp coming from stamps. For grinding coarser material pebbles up to 5 in. are suitable. At the start a mixture of large and small pebbles should be added, but after a mill has been in operation for some time the amount of smaller sizes of pebbles tends to increase due to reduction of diameter by wear and hence the proportion of large pebbles supplied to the mill should then be increased.

The load of pebbles is usually kept about up to the axis of rotation when smooth lining is used although South African practice on a 5.5-ft. tube mill is to keep it 3 in. above the axis of rotation.

The proper percentage of moisture varies under different conditions depending on the specific gravity, and coarseness and nature of the material to be ground. It should average from about 38 to 50 per cent. of the ore by weight.

For liners, silex blocks or smooth metal plates take up too much space or allow too much slip of pebbles. Rough liners of the Honeycomb, El Oro, or corrugated or ribbed types are considered best. Ribbed liners of the Komata type require a slower peripheral speed (330 ft. per minute for mills 4 to 5 ft. in diameter) and a reduction of the pebble load to a point 5 to 7 in. below the axis of rotation, depending on the diameter of the mill.

Putting aside the theories of impact and abrasion in tube mills, it may be said from a practical standpoint that the greater the movement of the pebbles the greater is the amount of grinding. Experience indicates that the grinding efficiency is materially increased by having a certain amount of very coarse sand constantly going in the tube mill along with the feed.

The critical moisture in wet tube-mill feed has been pretty well defined. It is not so well known perhaps that in dry tube milling a small percentage of moisture is very injurious.[1] A moisture content of 1 per cent. may reduce the capacity to one-half and 1.5 per cent. moisture has been known to cause the interior of the mill to become caked with fine ore.

[1] H. T. Durant, *Eng. and Min. Journ.*, Vol. XCIV (1912), p. 111.

*Theory of Crushing.*—The present tendency in comparing crushing and grinding plants to introduce the question of mechanical efficiency has led to a study of the energy required for rock crushing and the old fundamental principle of Rittinger that *force* required is proportional to increase of area has been discarded for that of Kick's law that *energy* absorbed in crushing is proportional to reduction in volume. The practical application of this law and the method of calculating "energy units" is due largely to Stadler (see MINERAL INDUSTRY, Vol. XIX, p. 748). Ball in his work on tube milling[1] recognized the law and adopted Stadler's method. More recently at McGill University[2] a large series of tests made for the express purpose of settling the truth of the theory has given results which agree with the law to within reasonable limits of error of experiment on so variable a material as broken rock. This work at McGill is now being continued with enlarged scope to study various machines to determine the most efficient range of each crushing machine, and the comparative efficiencies of the different machines. An early publication of results is promised.

Mr. A. Del Mar[3] has given a very lucid demonstration of the Rittinger and Stadler methods, making use of actual data, and in one case the Rittinger theory gives results which agree with the actual power measurements, while in two cases the Stadler method gives the best agreement. It is Del Mar's belief that the question as to the proper method to use is still open for discussion.

## SCREENING AND CLASSIFYING

*Grizzlies.*—The grizzlies at the Calumet and Hecla rock houses are arranged so that their slope may be quickly changed.[4]

*Trommels.*—An interesting test[5] has been made at the Desloge lead mill, Missouri, with 1-mm. hexagonal and conical trommels on material ranging from 10 mm. to 0.

The results of the tests were as follows: Oversize finer than 1 mm.; conical trommel, 7.02 per cent.; hexagonal trommel, 4.77 per cent.; life of jacket, conical trommel 7.1 days, 1065 tons; hexagonal trommel, 12.85 days, 1927 tons. The superiority of the hexagonal trommel is due to the greater agitation in it and to the obstruction which the interior rings of the conical trommel offer to the passage of the pulp. These rings caused the conical trommel to carry a heavier load which meant more wear and less efficient screening. Another advantage of the hexagonal

[1] *Inst. Min. and Met.*, Vol. XXI (1912), p. 3; *Min. and Sci. Press*, Vol. CIV (1912), p. 533.
[2] *Canadian Min. Journ.*, Vol. XXXIII (1912), p. 438; *Journ. Chem., Met. and Min. Soc., South Africa*, Vol. XIII (1912), p. 117; *Min. and Sci. Press*, Vol. CV (1912), p. 760.
[3] *Eng. and Min. Journ.*, Vol. XCIV (1912), p. 1129.
[4] C. T. Rice, *Eng. and Min. Journ.*, Vol. XCIII (1912), p. 159.
[5] *Eng. and Min. Journ.*, Vol. XCIV (1912), p. 833.

trommel was that one worn section could be replaced at a time without changing the entire screen.

Tests of slotted and round-hole punched steel screens at the Bunker Hill and Sullivan mill have led to the adoption of the former.[1]

The inefficiency of round-hole screens appears to be due to the fact that the mass of pulp is always on the up-hill side of the screen and therefore as is the case of any inclined screen, the ore particles have a tendency to slide over the holes instead of falling through. If the holes are lengthened into slots then the particles have no difficulty in dropping through. The finer the screen the greater is the necessity of lengthening the holes. It is obvious that if the longer dimension of the slot is placed parallel to the axis of the trommel then the advantage of slots over round holes entirely disappears.

*Fine Screening.*—For sizing fine dry ore in machines of the Vibromotor type, fine mesh wire and silk screens are used mounted on shaking or gyratory frames.[2] To secure highest efficiency it is essential that the rate of feeding be not too high. Over feeding means poor screening, excessive wear and blinding of the screens. When the feed contains flat fragments of ore the rate should be less than for granular feed. Screens should be well stretched and closely tacked at the edges. Fine screens need supporting wires or a coarse supporting screen to maintain a flat surface. The feed should be warmed to a temperature of 100 or 120° F. to avoid blinding or caking of the ore on the screen. Cleaning of fine silk screens may be accomplished without harm to the screen by the use of an ordinary short-bristle scrubbing brush made of Manila fiber or by a pressed tin lid like that used on small tin cans, used with its circular edge next to the screen. To avoid mistakes in replacing worn screens, a color system is very satisfactory, each size of screen, its frame and its position being painted a characteristic color. To prevent blinding rubber cone beaters are more efficient than any type of brushes, but they have the disadvantage that they wear rapidly.

*Testing Screens and Screen Analysis.*—The W. S. Tyler Company is prepared to supply standard screens which will be accurate and uniform in size of hole; this is of interest to millmen. At the outset this company had the courage to abandon the use of mesh as the fundamental designation for its screens and has substituted therefor the exact size of the hole, although as a matter of information the number of meshes per linear inch and the diameter of wire are part of the data supplied for each screen. The Tyler ratio is that of Rittinger and Richards—namely, $\sqrt{2}$ or 1.414 for ordinary work and $\sqrt[4]{2}$ or 1.189 for close sizing—but the

[1] R. S. Handy, *Eng. and Min. Journ.*, Vol. XCIV (1912), p. 1123.
[2] C. H. Brown, *Eng. and Min. Journ.*, Vol. XCIII (1912), p. 1281.

fundamental screen instead of being 1 mm. has been chosen as 0.0029 in. being the opening in a 200-mesh screen, 0.0021-in. wire, which is the standard sieve as adopted by the Bureau of Standards of the United States Government.

The following tables give the Tyler Standard screens.

FOR ORDINARY WORK.

| Opening in Inches. Ratio $\sqrt{2}$ or 1.414. | Opening in Millimeters. | Mesh. | Diameter of Wire, Inches. |
|---|---|---|---|
| 1.050 | 26.67 | ..... | 0.149 |
| 0.742 | 18.85 | ..... | 0.135 |
| 0.525 | 13.33 | ..... | 0.105 |
| 0.371 | 9.423 | ..... | 0.092 |
| 0.263 | 6.680 | 3 | 0.070 |
| 0.185 | 4.699 | 4 | 0.065 |
| 0.131 | 3.327 | 6 | 0.036 |
| 0.093 | 2.362 | 8 | 0.032 |
| 0.065 | 1.651 | 10 | 0.035 |
| 0.046 | 1.168 | 14 | 0.025 |
| 0.0328 | 0.833 | 20 | 0.0172 |
| 0.0232 | 0.589 | 28 | 0.0125 |
| 0.0164 | 0.417 | 35 | 0.0122 |
| 0.0116 | 0.295 | 48 | 0.0092 |
| 0.0082 | 0.208 | 65 | 0.0072 |
| 0.0058 | 0.147 | 100 | 0.0042 |
| 0.0041 | 0.104 | 150 | 0.0026 |
| 0.0029 | 0.074 | 200 | 0.0021 |

FOR CLOSER SIZING—65 TO 200 MESH.

| Opening in Inches. Ratio $\sqrt[4]{2}$ or 1.189. | Opening in Millimeters. | Mesh. | Diameter of Wire. Inches. |
|---|---|---|---|
| 0.0082 | 0.208 | 65 | 0.0072 |
| 0.0069 | 0.175 | 80 | 0.0056 |
| 0.0058 | 0.147 | 100 | 0.0042 |
| 0.0049 | 0.124 | 115 | 0.0038 |
| 0.0041 | 0.104 | 150 | 0.0026 |
| 0.0035 | 0.088 | 170 | 0.0024 |
| 0.0029 | 0.074 | 200 | 0.0021 |

The 100-mesh and the 20-mesh sieves of this scale also come within the specifications adopted by the U. S. Bureau of Standards. When necessary to carry a screen analysis finer than 200 mesh, sieves can be supplied as fine as 260 mesh in plain cloth and 300 mesh in twilled cloth. The firm is also prepared to supply specially ruled paper for direct logarithmic plotting of results of sizing tests.

It will be noted that the use of wire gage numbers has been entirely abandoned by the Tyler Company for direct measurements in decimals of an inch, and it is to be hoped that the use of meshes may soon go the same way.

With these standard screens in their hands the millmen of the country will be able to make direct comparison of their results with those of their fellows, much more easily than ever before.

Whether sizing tests should be made wet or dry has always been a question for debate. The Cananea Consolidated Copper Company[1] has adopted the wet method in the past as the most satisfactory.

Experiments have recently been made on a combined method in which, after the slime has been removed by the finest screen, the residue is dried and the remainder of the screening is performed dry. This semi-dry method has been found to give almost as good results as the wet system and to take only about half the time. The following table shows the exact results obtained in a few cases using wet, semi-dry and all dry methods.

SIZING TESTS OF WILFLEY AND FINE JIG TAILINGS (SOFT ORE).

| | Wet. | | Semi-dry. | | Wet. | | Dry. | |
|---|---|---|---|---|---|---|---|---|
| | Weight, Per cent. | Copper, Per cent. | Weight, Per cent. | Copper, Per cent. | Weight, Per cent. | Copper, Per cent. | Weight, Per cent. | Copper, Per cent. |
| On 20 mesh | 9.05 | 0.45 | 9.27 | 0.44 | 4.85 | 0.40 | 6.12 | 0.43 |
| Through 20 on 60 mesh | 36.20 | 0.44 | 36.22 | 0.47 | 38.87 | 0.40 | 41.08 | 0.44 |
| Through 60 on 100 mesh | 20.65 | 0.39 | 22.54 | 0.39 | 24.45 | 0.40 | 26.68 | 0.40 |
| Through 100 on 200 mesh | 11.90 | 0.43 | 11.07 | 0.47 | 4.87 | 0.48 | 16.60 | 0.48 |
| Through 200 on 240 mesh | 5.35 | 0.99 | 5.50 | 1.07 | 7.35 | 1.07 | 1.20 | 0.88 |
| Through 240 mesh | 16.85 | 1.27 | 15.40 | 1.36 | 20.68 | 1.27 | 8.32 | 1.33 |
| Time taken, minutes... | 120 | | 75 | | 130 | | 30 | |

Results on hard ore which slimes considerably less than soft ore showed a much closer agreement between the results of the wet method and the all-dry method.

*Pulsator Classifier.*—The Richards pulsator classifier of the inverted type has been much simplified.[2]

A critical discussion of the Richards pulsator classifier of the inverted type has been made by Mr. L. B. Skinner[3] who claims that it fails to employ a proper horizontal transporting agent for moving the material forward on the flat screen. This transporting movement is claimed to be accomplished actually but improperly by a diversion of part of the hydraulic water from its true function of a rising current to the improper function of horizontal current. This horizontal current is sufficient to carry forward to later compartments fine particles which should have been lifted in earlier compartments. Furthermore, the bed of ore is said not to be uniform and the classifier is sensitive to changes in the feed.

To overcome these difficulties and lessen water consumption Mr. Skinner has tried a modification of the Richards classifier in which the screen

[1] A. T. Tye, *Min. and Sci. Press*, Vol. CV (1912), p. 339.
[2] *Eng. and Min. Journ.*, Vol. XCIII (1912), p. 896; *Min. Mag.*, Vol. VI (1912), p. 453.
[3] L. B. Skinner, *Colorado Scientific Society*, Vol. X (1912), p. 123; *Met. and Chem. Eng.*, Vol. X (1912), p. 343; *Min. Mag.*, Vol. VII (1912), p. 63.

bed is inclined downward from the feed to discharge end and the hydraulic water is introduced horizontally to assist in the forward movement of the bed; also in another modification the whole classifier is given a shaking motion, the water jets still remaining horizontal but the slope of the screen varying on a curve which is steep at the feed end and nearly flat at the discharge end.

In reply to Mr. Skinner's criticism it may be said that the bed of ore in the Richards classifier is assumed to be of the nature of a jig bed and therefore so mobile that the particles are moved forward from one compartment to the next by virtue of the greater hydrostatic head in the first compartment in just the same manner as in a side discharging jig where the concentrates make their way under the partition separating the jig bed from the discharge compartment and thence pass over a dam into the concentrates hopper.

*Mechanical Classifier.*—A new form of mechanical classifier called the Major classifier, has been installed at the new Minnesota mill, South Dakota.[1] It consists of a cylinder or barrel, 6 feet in diameter and 9 feet in length, lying on its side and revolving on roller bearings 1 1/2 to 2 times per minute. The interior of the cylinder is divided into two compartments by an annular partition that projects inward. The interior of the cylinder is provided with riffles or blades projecting inward 1 inch and set about 9 inches apart. The feed is introduced by a launder and as the cylinder revolves the blades agitate the mass and pick up the heavy portion or sand, carrying it to a point near the top of the cylinder where it drops to a tray.

*Classifying Sand and Slime.*—In classifying stamp mill pulp in South Africa,[2] the spitzlutten in series are still commonly used. These work well except in some cases the feed launder is too steep causing the feed to enter at too high a velocity. This may be remedied by widening the feed launder or increasing the height of the overflow so as to break up the feed water. A preliminary screen is desirable to prevent clogging of the spigot by large particles of ore. A classifier giving a liquid underflow adjusts itself to changed conditions of feed much better than the diaphragm classifier which gives a thick spigot product. With the latter an increased feed means in a short time that the character of the overflow will become coarser. Investigations are under way with some promise of success, looking toward the development of some automatic method of governing the amount of spigot product according to the amount of coarse material in the feed. At one mine an improvement in the work of the diaphragm

[1] J. Simmons, *Min. and Eng. World*, Vol. XXXVII (1912), p. 813. *Eng. and Min. Journ.*, Vol. XCIV, (1912), p. 977.

[2] G. A. Robertson, *South African Min. Journ.*, Sept., 1912, p. 334; *Met. and Chem. Eng.*, Vol. X, (1912), p. 793.

classifier was made by installing a 1-in. water jet just below the diaphragm, thus adding the necessary amount of water to the spigot product and at the same time discharging it at high velocity.

Where cone classifiers are used with a central feed pipe the difficulty sometimes occurs that banks of fine sand are formed. This may be remedied by drawing in the sides of the cone above the level of the bottom of the feed pipe so that the rising current increases above this level and carries up any particle of sand that would form banks in the usual form of cone.

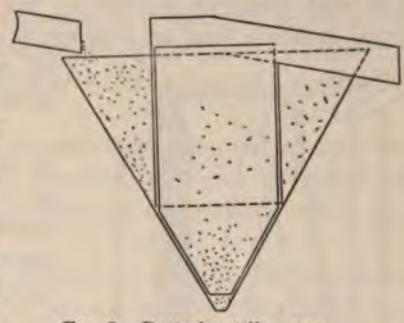


FIG. 2.—Butter's settling cone.

To prevent air from being carried down the central feed pipe and disturbing the work of the classifier, the bottom of the feed pipe may be partly closed by a self-regulating circular plate which maintains a head of water in the feed pipe.

For best results classification of products of two different grades should usually be performed in separate classifiers, that is, stamp-mill pulp and tube-mill pulp should not go as a rule to the same classifier.

Settling cones of the ordinary type are fed through the central cylinder and overflow at the edges. The Butters Company uses a modified cone[1] which is fed at the periphery. The central cylinder is made larger (see Fig. 2) for the rising current The whole cone is made smaller and thus mill height is saved. The annular space between the side of the cylinder and the cone is 1/2 to 5/8 in. The cylinder is divided by a vertical partition extending to near the point of the cone. This prevents the vortex which would otherwise be formed by the discharge of the spigot.

The Stanley classifier[2] has been invented for the retreatment of gold mill tailings on the Rand. As shown in Fig. 3, it is a combined classifier and screen, a fine screen preventing the coarse light grains from passing into the overflow. Pulp is fed at *a* and as it passes through the constricted part *d* its velocity is increased. The heavier and larger particles fall through the slot *j* into the receptacle *k* where the hydraulic equilibrium is preserved by the water inlet *e*. On rising into the space between the partition *b* and the screen *f* the current once more slackens and thus the larger particles of low specific gravity that will not pass the screen fall down on the side of the compartment nearest the screen and are

[1] D. Waterman, *Min. and Sci. Press*, Vol. CIV (1912), p. 567; *Min. Mag.*, Vol. VI (1912), p. 457.

[2] *Aus. Min. Stand.*, June 6, 1912; *South African Min. Journ.*, Dec. 16, 1911; *Min. and Eng. World* Vol. XXXVI (1912), p. 1198; *Min. Mag.*, Vol. VI (1912), p. 141; *Eng. and Min. Journ.*, Vol. XCIV (1912), p. 317; *Min. and Eng. World*, Vol. XXXVI (1912), p. 772; *Am. Met. Soc.*, Vol. 1 (1912), p. 108; *Met. and Chem. Eng.*, Vol. X (1912), p. 558.

able to make their way to the slot *j* without interference with the upward current that is strongest on the side nearest the partition.

The old tailings are classified into three products: (1) material coarser than 60 mesh containing most of the pyrite, (2) fine material below 60 mesh, (3) slime. The last two products can be cyanided direct while the first requires regrinding before cyaniding. Tests at the Robinson mine indicate that an average extraction of 75 per cent. can be obtained at a cost of $0.50 per ton on material averaging $1 to $1.50 per ton.

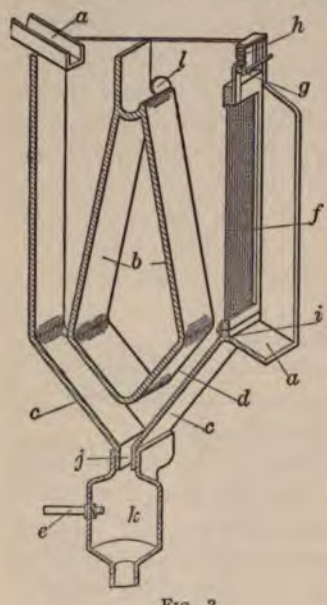



FIG. 3.

The losses that occur in slimes, especially in ores containing sulphides of lead, copper or zinc, are not always realized. In a specific case[1] a Ferraris table treating a classified product containing slate, quartz, spathic iron and copper sulphides with 1.6 to 1.8 per cent. copper made the following products: Concentrates with 14 to 16 per cent. copper; spathic iron with 5 to 7 per cent. copper, middlings with about 1.5 per cent. copper, tailings with 0.2 to 0.3 per cent. copper, and slimes with 1 to 2 per cent. copper. In the mill of the Mittenburger Copper Company the combined slimes from 15 tables contained 375.2 liters of water and 7.819 kilos of solid per minute or about 0.5 ton per hour with an assay of 1.15 per cent. copper. Jig tailings in the same mill assay only 0.6 or 0.7 per cent. copper.

Much of this value may be saved by one of the flotation processes but these processes with the exception of the Elmore and Macquisten require that the pulp be thickened or unwatered until it contains not less than 10 per cent. of solids. This unwatering may be done in spitzkasten but the overflow will assay 1.8 to 2.0 per cent. copper and this is lost.

Knudsen has installed for the Mittenburger Company a filtering spitzkasten having a screen across the top which screen supports a bed of broken ore in sizes of from 5 to 11 mm. The pulp is delivered through a vertical pipe passing down through the screen. Settlings are drawn off through a bottom spigot in the usual manner while the rising water comes up through the screen and filter where it is relieved of its solid contents, and overflows around the sides of the spitzkasten. The principle is the same as that of sand filtration used for some domestic water supplies.

[1] M. Moldenhauer, *Metallurgie*, Vol. IX (1912), p. 99; *Revue de Metallurgie Extraite*, Vol. IX (1912) p. 378.

In a test such a spitzkasten without the filter bed yielded an overflow 9 liters of which contained 35.7 grm. of solids assaying 1.67 per cent. copper. The same spitzkasten with filter bed 12 cm. deep yielded an overflow with 4.7 grm. of solids in 9 liters and assaying 0.77 per cent. copper. The filter becomes choked with slime after 40 to 60 hours and must be washed. For best work it is essential that the feed carry down no air to rise up again through the filter. One square meter of filtering surface can handle about 0.5 liter per second. It takes two men from 5 to 8 minutes to clean the filter.

This apparatus has not only the advantages of eliminating water from slime so that further concentration is possible, but also of removing slime from water so that the clarified water may be pumped back and used again in the mill.

*Settling Slimes.*—The question of settling of mill slimes has been discussed and two papers have appeared giving results and conclusions which are not entirely harmonious. D. L. H. Forbes[1] gives report of tests on four classes of slime. No. 1 slime is a clayey slime with 96.5 per cent. through 200 mesh and with 0.042 per cent. cyanide in solution. No. 2 slime clayey, 84.6 per cent. through 200 mesh, trace of cyanide and lime in solution. No. 3 slime, quartzose, 74.2 per cent. through 200 mesh, 0.15 per cent. cyanide and 0.09 per cent. lime in solution. No. 4 slime is a mixture of Nos. 2 and 3.

Graphical plots and tables of results in the original article show that the more dilute the slime at the start the faster it settles. Slimes Nos. 1 and 2 do not settle beyond a ratio of liquid to solid of 4 : 1, while slime No. 4 reaches a limit of practical settlement at the ratio 1.15 : 1. Lime unless in excess accelerates the settling. Where settling efficiency is defined as the ratio of solution settled clear to the original volume of pulp it is found in nearly every case that the settling efficiency for a given dilution and time diminishes as the original depth of the pulp is increased and therefore the conclusion is drawn that tanks as shallow as practicable should be used in actual mill work. The settling efficiency is considerably increased when the settling column is inclined from the vertical thus showing the advantage of the DeKalb or Gardner inclined baffle plates.

The following conditions are believed to govern the rate of settling of slime in still water: (1) The size and shape of the slime particles; (2) the percentage of colloids present; (3) the dilution of the pulp; (4) the height of the column of pulp in which settling takes place irrespective of the size or shape of the horizontal cross-section; (5) the average specific gravity of the slime particles; (6) the presence and amount of electrolytes in the water.

[1] *Eng. and Min. Journ.*, Vol. XCIII (1912), p. 411.

For practical use it is proposed to adopt an arbitrary set of standard conditions under which the comparative efficiencies may be determined. Such a scale is shown in Fig. 4 where the abscissæ represent the dilution of the pulp and the ordinates represent efficiency expressed as per cent. water settled clear out of the original pulp. The place where the curve

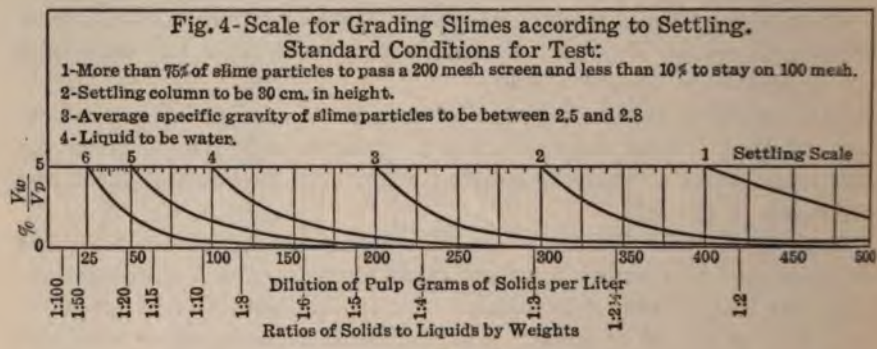


Fig. 4-Scale for Grading Slimes according to Settling.
Standard Conditions for Test:
1-More than 75% of slime particles to pass a 200 mesh screen and less than 10% to stay on 100 mesh.
2-Settling column to be 30 cm. in height.
3-Average specific gravity of slime particles to be between 2.5 and 2.8
4-Liquid to be water.
6 5 4 3 2 1 Settling Scale
5
% Vw/Vp
0
25 50 100 150 200 250 300 350 400 450 500
Dilution of Pulp Grams of Solids per Liter
1:100 1:50 1:20 1:15 1:10 1:8 1:6 1:5 1:4 1:3 1:2½ 1:2
Ratios of Solids to Liquids by Weights

of any slime cuts the 5 per cent. efficiency line determines the number of that slime in the settling scale. For example, the division 1 on the scale corresponds to a settling efficiency of 5 per cent. at the dilution of 400 grm. to the liter and so on up to No. 6 where settling is so difficult that an efficiency of 5 per cent. is obtained only in the very dilute condition of 25 grm. per liter. Fig. 5 represents an attempt to make graphical use

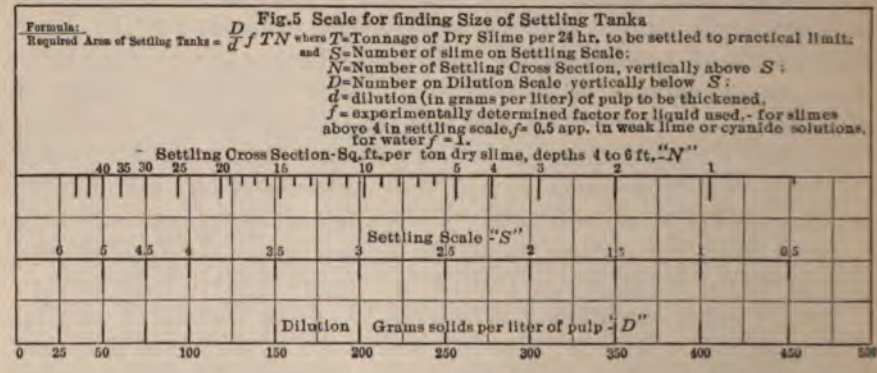


Fig. 5 Scale for finding Size of Settling Tanks
Formula:
Required Area of Settling Tanks = D/d f TN where T=Tonnage of Dry Slime per 24 hr. to be settled to practical limit;
and S=Number of slime on Settling Scale:
N=Number of Settling Cross Section, vertically above S;
D=Number on Dilution Scale vertically below S;
d=dilution (in grams per liter) of pulp to be thickened,
f=experimentally determined factor for liquid used,- for slimes above 4 in settling scale, f=0.5 app. in weak lime or cyanide solutions, for water f=1.
Settling Cross Section-Sq. ft. per ton dry slime, depths 4 to 6 ft.-"N"
40 35 30 25 20 15 10 5 4 3 2 1
Settling Scale "S"
6 5 4.5 4 3.5 3 2.5 2 1.5 1 0.5
Dilution Grams solids per liter of pulp-"D"
0 25 50 100 150 200 250 300 350 400 450 500

of a formula in determining the proper area of settling tank in a mill. It is not clear from the original article whether the correctness of this formula has been tested out in large mill tanks.

Some tests on the settling of slimes in regular mill solutions containing small percentages of cyanide and lime have been made at the Tigre mill,

Sonora, Mexico.[1] The character of the slimes varied all the way from almost pure clay to comparatively clean reground sand with ratio of liquid to solid varying all the way from 2:1 to 60:1. The results indicate that in settling a dilute slime to a desired degree of thickness in a jar with continuous feed and overflow the average rate of settling is virtually independent of the depth of settling column. The rate of settling at the start is greater in a shallow than in a deep column, but the settling rate in the deep column increases, thus equalizing the first advantage gained by the shallow column. However, a shallow tank is practically as efficient as a deep tank and both tanks receiving the same feed per day will produce the same volume of clear solution per day and yield the same volume of pulp per day thickened to the same consistency. There is a practical limit to the use of shallow tanks because if discharged intermittently, the shallow tank will require too frequent discharging, or if discharged continuously the shallow tank will not lend itself so readily to proper distribution of feed and regulation of underflow. Table No. 1 gives the results of tests on thin slime, using a continuous settler made from a glass carboy 2 ft. high and 1.15 ft. in diameter. Table No. 2 contains results of quiet settling of thin pulp in a glass cylinder, 2.3 ft. high and 0.1 ft. in diameter. Slime No. 1 was principally flocculent particles of clay. It had 98 per cent. finer than 200 mesh. The solution contained a trace of cyanide and 0.1 lb. of lime per ton. In No. 2 slime which was a mixture of slime No. 1 with fine particles of sand, 90 per cent. was through 200 mesh and the solution had trace of cyanide and 0.1 lb. of lime per ton. No. 3 slime was principally sand with 80 per cent. finer than 200 mesh and solution with 0.16 per cent. cyanide and 2.0 lb. of lime per ton. No. 4 was a mixture of the first three, 85 per cent. through 200 mesh, solutions 0.17 per cent. cyanide and 1.9 lb. of lime.

TABLE 1.—EFFECT OF DEPTH ON RATE OF CONTINUOUS SETTLING OF THIN SLIME.

| Test. | Slime No. | Depth of Column, Feet. | Duration of Test, Mintues. | Ratio, Liquid to Solid. | | Cubic Feet, Feed per Minute. | Cubic Feet, Overflow per Minute. |
|---|---|---|---|---|---|---|---|
| | | | | Feed. | Discharge. | | |
| A..... | 3 | 1.4 | 77 | 5 : 1 | 3.5 : 1 | 0.047 | 0.0139 |
| B..... | 3 | 0.7 | 33 | 5 : 1 | 3.5 : 1 | 0.048 | 0.0139 |
| C..... | 1 | 1.4 | 53 | 24 : 1 | 17 : 1 | 0.021 | 0.0066 |
| D..... | 1 | 0.7 | 65 | 24 : 1 | 17 : 1 | 0.024 | 0.0068 |
| E..... | 1 | 0.35 | 20 | 24 : 1 | 20 : 1 | 0.026 | 0.0047 |
| F..... | 1 | 0.35 | 10 | 24 : 1 | 16 : 1 | 0.019 | 0.0064 |

In the case of thick slimes the rate of settling does not follow the foregoing principle but it increases with the depth of the settling column. See Table III.

R. T. Mishler, *Eng. and Min. Journ.*, Vol. XCIV (1912), pp. 643, 872, 1114.

TABLE II.—EFFECT OF DEPTH ON RATE OF SETTLING OF THIN PULP.

| Height of Settling Column in Feet. | Duration of Test in Minutes. | Ratio, Liquid to Solid | | Depth of Clear Solution at End of Test, Feet. | Depth of Clear Solution Formed per Minute, Feet. |
|---|---|---|---|---|---|
| | | Beginning of Test. | End of Test. | | |
| **Slime No. 1.** | | | | | |
| 0.66 | 10 | 10 : 1 | 9.2 : 1 | 0.05 | 0.005 |
| 1.33 | 20 | 10 : 1 | 9.2 : 1 | 0.11 | 0.005 |
| 2.00 | 30 | 10 : 1 | 9.2 : 1 | 0.16 | 0.005 |
| 0.66 | 10 | 30 : 1 | 24.9 : 1 | 0.11 | 0.011 |
| 1.33 | 20 | 30 : 1 | 24.8 : 1 | 0.23 | 0.011 |
| 2.00 | 30 | 30 : 1 | 25.2 : 1 | 0.37 | 0.012 |
| 0.66 | 10 | 60 : 1 | 24.0 : 1 | 0.39 | 0.039 |
| 1.33 | 20 | 60 : 1 | 24.7 : 1 | 0.76 | 0.038 |
| 2.00 | 30 | 60 : 1 | 26.7 : 1 | 1.09 | 0.036 |
| **Slime No. 2.** | | | | | |
| 0.66 | 10 | 8.5 : 1 | 7.9 : 1 | 0.04 | 0.004 |
| 1.33 | 20 | 8.5 : 1 | 7.9 : 1 | 0.09 | 0.004 |
| 2.00 | 30 | 8.5 : 1 | 7.9 : 1 | 0.13 | 0.004 |
| 0.66 | 10 | 15 : 1 | 13.1 : 1 | 0.08 | 0.008 |
| 1.33 | 20 | 15 : 1 | 13.1 : 1 | 0.17 | 0.008 |
| 2.00 | 30 | 15 : 1 | 13.1 : 1 | 0.23 | 0.008 |
| 0.66 | 10 | 25 : 1 | 18.2 : 1 | 0.18 | 0.018 |
| 1.33 | 20 | 25 : 1 | 18.2 : 1 | 0.35 | 0.018 |
| 2.00 | 30 | 25 : 1 | 18.3 : 1 | 0.52 | 0.017 |
| **Slime No. 3.** | | | | | |
| 0.66 | 10 | 3.0 : 1 | 2.2 : 1 | 0.15 | 0.015 |
| 1.33 | 20 | 3.0 : 1 | 2.2 : 1 | 0.28 | 0.014 |
| 2.00 | 30 | 3.0 : 1 | 2.3 : 1 | 0.41 | 0.014 |
| 0.66 | 10 | 4.5 : 1 | 3.1 : 1 | 0.18 | 0.018 |
| 1.33 | 20 | 4.5 : 1 | 3.2 : 1 | 0.38 | 0.019 |
| 2.00 | 30 | 4.5 : 1 | 3.2 : 1 | 0.52 | 0.017 |
| 0.66 | 10 | 7.0 : 1 | 4.2 : 1 | 0.25 | 0.025 |
| 1.33 | 20 | 7.0 : 1 | 4.2 : 1 | 0.50 | 0.025 |
| 2.00 | 30 | 7.0 : 1 | 4.3 : 1 | 0.74 | 0.025 |

TABLE III.—EFFECT OF DEPTH AND INITIAL THICKNESS OF PULP ON SETTLING RATE OF THICK SLIMES. (*a*)

| Slime No. | Ratio, Liquid to Solid. | | Depth in Feet of Clear Solution Formed per Minute. | | |
|---|---|---|---|---|---|
| | Beginning of Test. | End of Test. | Depth of Column ½ ft. | Depth of Column 1 ft. | Depth of Column 2 ft. |
| 4 | 1.9 : 1 | 1.8 : 1 | 0.0001 | 0.0001 | 0.0002 |
| 4 | 2.1 : 1 | 2.0 : 1 | 0.0002 | 0.0002 | 0.0004 |
| 4 | 2.7 : 1 | 2.6 : 1 | 0.0002 | ..... | 0.0009 |
| 4 | 3.2 : 1 | 3.0 : 1 | 0.0003 | 0.0004 | 0.0012(*b*) |
| 4 | 3.6 : 1 | 3.4 : 1 | 0.0004 | ..... | 0.0045 |
| 4 | 4.5 : 1 | 4.3 : 1 | 0.0009 | 0.0031 | 0.0072 |
| 4 | 4.7 : 1 | 4.5 : 1 | 0.0014 | 0.0067(*b*) | 0.0073 |
| 4 | 5.0 : 1 | 4.7 : 1 | 0.0014(*b*) | 0.0090 | 0.0087 |
| 4 | 6.5 : 1 | 6.2 : 1 | 0.0092 | 0.0092 | 0.0090 |
| 1 | 6.0 : 1 | 5.7 : 1 | 0.0001 | 0.0001 | 0.0001 |
| 1 | 8.0 : 1 | 7.6 : 1 | 0.0002 | 0.0003 | 0.0004(*b*) |
| 1 | 9.0 : 1 | 8.5 : 1 | 0.0007 | 0.0021(*b*) | 0.0042 |
| 1 | 12.0 : 1 | 11.4 : 1 | 0.0009 | 0.0087 | 0.0092 |
| 1 | 14.0 : 1 | 13.3 : 1 | 0.0032(*b*) | 0.0092 | 0.0094 |
| 1 | 17.0 : 1 | 16.1 : 1 | 0.0067 | 0.0095 | 0.0092 |

(*a*) Quiet settling in glass cylinder 0.1 ft. diameter. Each test made by noting time required to form a volume of clear solution equal to 1/20 part of original volume of pulp. (*b*) Below this point the slime begins to follow the principles of settling for thin pulp.

It has been found that the results of these laboratory tests may be applied to large mill tanks and two formulas have been derived which have been proved to be correct by checking them up with the actual result in the Tigre mill.

Let $S$ be the rate of settling expressed in terms of depth in feet of clear solution formed per minute.

Let $F$ be the feed of dry slime expressed in tons per 24 hours.

Let $A$ be the settling area expressed in square feet.

Let $R_1$ be the ratio liquid to solid in feed (6:1 expressed by the figure 6).

Let $R_2$ be the ratio liquid to solid in underflow (expressed as above).

Then

Tons of clear solution per day $=F\ (R_1-R_2)$

Cubic feet of clear solution per minute=

$$\frac{32F\,(R_1-R_2)}{1440}=0.0222\,F\ (R_1-R_2)$$

Depth in feet of clear solution formed per minute=

$$\frac{0.0222\ F\ (R_1-R_2)}{A}=S$$

$$\text{or } A=\frac{0.0222\,F\ (R_1-R_2)}{S}$$

To save computation the data obtained by this formula may be expressed graphically as a curve plotting $R_1$ as abscissæ and $S$ as ordinates.

Summarizing the work of the year on slime settling it seems that our knowledge of the subject has been considerably increased and it is to be hoped that further work may be done in the future on the lines already laid out to determine whether slimes from other grades of ore will be found to be governed by the same laws as those already investigated and also to determine whether in all cases the results of laboratory tests can be applied to large scale mill work.

## Jigs and Tables

*Jigs.*—In jigging smithsonite ore in a dolomite gangue six Harz jigs are reported to have been replaced by one roughing and one cleaning jig with improved results.[1] There were four Harz jigs with three compartments each, and two Harz jigs with four compartments each. The feed was sized 1/2 in. to 3/8 in. to two jigs, 3/8 in. to 3/16 in. to two jigs, 3/16 to 3/32 in. to one jig and classifier spigot to one jig.

The Overstrom jigs installed in the mill of the St. Louis Smelting &

[1] R. Reddie, *Mines and Minerals*, Vol. XXXIII (1912), p. 170.

Refining Co. in Southeastern Missouri[1] are of the Harz type with screen 3×5 ft. and one plunger. The bed is divided in two parts by a cross partition and the hutch below is similarly divided, thus making the jig virtually two-compartment with one plunger.

An improvement in the Hancock jigs at the No. 3 mill of the Doe Run Lead Company in Southeastern Missouri[2] consists of a steel frame for holding the screens of the movable sieve.

*Riffle Tables.*—In the Joplin district of Missouri, the Wilfley tables have certain features for improving their work.[3]

A testing table is used at the Coniagas mill at Cobalt to check the work of the mill tables.[4] A sample is taken automatically from the mill tailings and this is re-run over the testing table to determine whether too much value is going to waste.

*Tables for Slimes.*—The James Diagonal Plane Slimer[5] is a modification of the James Diagonal Plane Concentrating Table (see MINERAL INDUSTRY, Vol. XX, p. 827). It is a rectangular riffled table of the Wilfley type with a feed box 10 ft. long. The feed pulp is first stratified in flowing over a gently sloping smooth plane *A*, Fig. 6, extending the full length of the

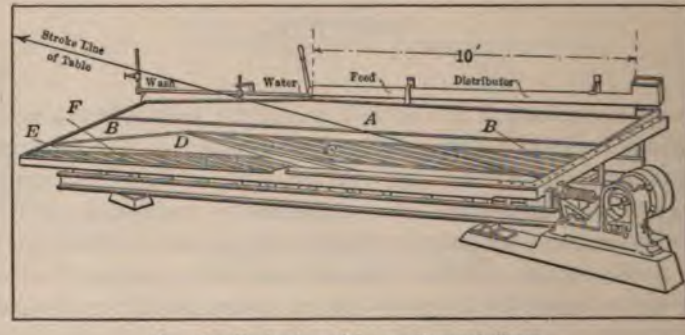



FIG. 6.—Deck view of James diagonal slimer.

feed side. The pulp next meets a smooth narrow plane *B* extending parallel to *A* and widening out in its last 4 ft. next to the concentrates end of the table. This plane *B* retards the settled concentrates and a small portion of the gangue and allows the feed water and most of the gangue to flow across it upon a riffled plane *C*. This plane *C* terminates 4 ft. short of the concentrates end. The riffles are inclined parallel to a line connecting the corner between the mechanism end and the tailings side with the corner between the feed side and the concentrates end. This line of

[1] *Eng. and Min. Journ.*, Vol. XCIV (1912), p. 351.
[2] *Eng. and Min. Journ.*, Vol. XCIII (1912), p. 1177.
[3] C. T. Rice, *Eng. and Min. Journ.*, Vol. XCIII (1912), p. 1129.
[4] *Eng. and Min. Journ.*, Vol. XCIV (1912), p. 690.
[5] S. A. Krom, *A. I. M. E., Bulletin* No. 66, June, 1912, p. 649.

the riffles is also the line of the bumping motion of the table. The riffles on *C* serve to collect any fine particles of concentrates that may have been washed across *B* and to deliver them back to *B* to be discharged at the concentrates end. The gangue which is washed across *C* is discharged over the tailings side of the table. In the remaining four feet of the table between plane *C* and the concentrates end are two smooth planes *D* and *E* and a riffled plane *F*. These three planes are similar in action and in arrangement, but on a smaller scale, to the planes *A*, *B* and *C* and they serve to re-treat any material that is washed across the wide portion of *B* and to recover concentrates from it which are delivered over the concentrates end.

The multiplication of planes is designed to make the table more efficient than the ordinary table of the Wilfley type. Comparisons of the work of this table with that of vanners or that of ordinary Wilfley type tables show that it effects a considerably higher extraction by reducing the tenor of the tailings, but that it makes a slightly lower grade concentrate.

The Darrow-Hambric rotary table[1] is in reality a canvas plant condensed into one machine. It has already replaced the old canvas plants at four of the large mines on the mother lode in California.

For treatment of slime Wilfley has devised a multiple deck slime table.[2] This consists of a series of twelve decks one above the other, 1 1/4 in. apart, all mounted in a shaking frame receiving motion from an eccentric making 225 revolutions per minute. Each deck is 6×12 ft. and is covered with linoleum in which are cut 126 parallel curved grooves 1/16 in. deep and 1/2 in. wide, and separated by a plane surface averaging 1/8 in. in width. The grooves extend the full length of the deck approximately parallel to the line of motion. The flow of pulp is across the table. A feed box and a distributor are provided, and the table works automatically through the following cycle. (1) Table flat, pulp introduced spread over the surface and agitated. (2) Table slightly tipped, feed shut off and dirty water introduced to wash off light gangue. (3) Table radically tipped and clean water introduced to wash off the concentrates. The capacity of the complete table is said to be equal to that of eight vanners or about 40 or 50 tons in 24 hours.

The Nevada Consolidated mill has installed the Craven double deck canvas tables to attack the problem of slime losses.[3]

The Deister Machine Company have introduced an automatic multi-deck table having six rectangular decks one above the other, each covered

[1] A. H. Martin, *Mines and Minerals*, Vol. XXXII (1912), p. 428; *Min. and Eng. World*, Vol. XXXVI (1912), p. 668; *Am. Met. Soc.*, Vol. I (1912), p. 114; *Eng. and Min. Journ.*, Vol. XCIV (1912), p. 542; *Eng. Mag.*, Vol. XLIV (1912), p. 425.
[2] C. J. Downey, *Min. Sci.*, Vol. LXVI (1912), p. 52; *Min. Mag.*, Vol. VII (1912), p. 221.
[3] *Eng. and Min. Journ.*, Vol. XCIV (1912), p. 301.

with a specially prepared surface. These decks are mounted on common supports and are fed simultaneously over any desired interval of time. When the decks become charged with concentrates they are all automatically reversed in inclination, the feed being cut off and the wash water for removal of concentrates turned on at the same time.

The advantage of canvas surfaces in work on slimes is that they are able to save fine particles that escape other machines, thus producing cleaner tailings but at a sacrifice of the quality of the concentrates. A series of tests on lead slimes of the Joplin district, Missouri, made on fixed canvas tables and on Overstrom tables bring out this point.[1] The following figures are representative of the general character of the results obtained. Canvas table feed 2.00 per cent. lead; concentrates 55.40 per cent. lead; tailings 1.08 per cent. lead; Overstrom table feed 2.38 per cent. lead; concentrates 64.60 per cent. lead; tailings 1.13 per cent. lead.

## AMALGAMATION

The gold milling practice at the Homestake mill, South Dakota, has been described in Richards Ore Dressing, Vol. II, p. 1025, and Vol. IV, p. 1639 and the new regrinding plant in MINERAL INDUSTRY, Vol. XX, p. 370. The following notes give some of the details and improvements especially in the amalgamation work.[2]

Electric power is to be installed with separate motors for every ten stamps. Chrome adamantine steel is used for cams and tappets where the drop is 10 in. and iron where the drop is 8 1/2 in. An order of drop of 1, 4, 2, 5, 3, has been found to have a slight advantage. The wood lining of the Major individual stamp stem guides has been replaced with cast iron which gives less friction and less cost of renewals. Back liners or back plates are no longer used in the mortars. The mortar blocks are built of 2-in. pine plank preserved by creosoting which has a very long life. A No. 8 diagonal needle slot screen with slots 0.022×0.5 in. in 0.035-in. steel plate, equivalent in discharge to a 30- or 35-mesh wire screen, has been found to excel on average ore the coarser No. 6 or No. 7 screens formerly used. On oxidized ore a coarser screen of wire with slots 0.023×0.052 in. is used to give a faster discharge. Screens last 10 to 12 days and are cleaned by beating with the frayed end of a 3-ft. strand of wire rope. Several years ago the flosh or overflow system without screens was tried and gave good results provided the mill was carefully fed and watched, but it was finally given up. Chip screens, 30×48 in.

[1] E. W. Busket, *Min. and Eng. World*, Vol. XXXVI (1912), p. 456; *Am. Met. Soc.*, Vol. I (1912) p. 103.

[2] A. J. Clark and W. J. Sharwood, *Inst. Min. and Met. Bulletin* No. 98; *Min. and Eng. World*, Vol. XXXVII (1912), pp. 1035, 1090, 1142, 1189; *Min. and Sci. Press*, Vol. CV (1912), p. 762.

with 7-mm. holes are placed after the first and last rows of plates to catch wood.

Mercury is fed to the battery every hour. Details of mercury amalgam and bullion are given in the table.

| | Troy Ounces per Ton Milled. | | | | |
|---|---|---|---|---|---|
| | Average. | Low-grade Oxidised Ore. | | Fairly High-grade Unoxidised Ore. | |
| Mercury fed to mortars (*a*) | 0.30 | 0.27(*b*) | 0.20 | 0.33 | 0.364 |
| Total amalgam obtained | 0.55 | 0.30 | ..... | ..... | 0.80 |
| Containing: | | | | | |
| Crude bullion | 0.18 | 0.12 | ..... | ..... | 0.26 |
| Valued at | $2.92 | $1.93 | $1.00 | $3.70 | $4.12 |
| And mercury from retort | 0.37 | 0.18 | ..... | ..... | 0.54 |
| Mercury lost in tailings | 0.132 | 0.085 | 0.09 | 0.17 | ..... |
| Mercury found in precipitate: | | | | | |
| At slime plant | 0.014 | ..... | ..... | ..... | ..... |
| At slime plant No. 1 | 0.001 | ..... | ..... | ..... | ..... |

(*a*) Additional mercury used on outside plates and in cleaning amalgam. (*b*) In this case 0.08 oz. mercury used on outside plates.

It has not been found profitable to attempt to recover the mercury in the slime plant precipitate. About 1/4 oz. mercury per square foot is required to set new plates plated with 2 oz. silver per square foot. With silvered-plates the best conditions are maintained when the temperature of the mill water is about 50° F. Higher temperature tends to cause mercury to separate out and run down into the traps leaving hard amalgam behind. Dressing the plates oftener than once in 24 hours tends to catch rather less on the upper plate and more on the lower as shown by table.

| | Amalgam Recovered when Plates Dressed., | |
|---|---|---|
| | Once daily | Twice daily |
| Second row | $491 | $451 |
| Third row | 240 | 248 |
| Fourth row | 120 | 128 |
| Total from silvered plates | $851 | $827 |
| Relative value | 100 | 97.2 |

In the regrinding department the seven Wheeler grinding pans 5 ft. in diameter have been tried out against the tube mill, 5×14 ft. The comparative figures are shown in the two accompanying tables.

SIZING TESTS ON FEED AND DISCHARGE OF PANS AND TUBE MILLS.

| | Feed. | | | | Discharge. | | | |
|---|---|---|---|---|---|---|---|---|
| | Weight, Per Cent. | Pyrite, Per Cent. | Insoluble Per Cent. | Gold Per Ton. | Weight, Per Cent. | Pyrite, Per Cent. | Insoluble Per Cent. | Gold Per Ton. |
| On 50 mesh | 38.4 | 2.38 | 78.0 | $2.00 | 4.0 | 1.45 | 79.9 | $1.31 |
| Through 50 on 80 mesh | 42.0 | 7.55 | 67.9 | 2.97 | 12.5 | 2.85 | 75.1 | 1.68 |
| Through 80 on 100 mesh | 9.9 | 22.2 | 53.0 | 4.66 | 13.5 | 5.96 | 73.2 | 1.77 |
| Through 100 on 200 mesh | 6.8 | 30.0 | 46.0 | 5.40 | 28.0 | 9.93 | 71.3 | 2.05 |
| Through 200 mesh | 2.9 | 25.2 | 49.3 | 4.43 | 42.0 | 11.65 | 65.1 | 2.33 |
| Average | 100.0 | 9.1 | 68.4 | 2.98 | 100.0 | 8.85 | 70.1 | 2.05 |

WORK OF PANS AND TUBE MILLS.

| | Pans. | | Tube Mill. | | Tube Mill. | |
|---|---|---|---|---|---|---|
| | 12,308 Tons Ground by 7 Pans. | | Regular Adjustment Medium Feed. | | Special Adjustment Heavy Feed. | |
| Total tons ground per day | 19.34 per pan | | 73 | | 110.0 | |
| Tons through 100 mesh per day | 10.83 per pan | | 43 | | 52.8 | |
| Water in feed, per cent | 80–90 | | 38 | | 38.4 | |
| Gold value per ton | Feed. $2.66 | Discharge. $2.07 | Feed. $2.49 | Discharge. $2.04 | Feed. $2.49 | Discharge $2.04 |
| On 50 mesh | 47 | 6 | 39 | 5 | 18 | 7 |
| Through 50 on 80 mesh | 34 | 14 | 38 | 12 | 49 | 15 |
| Through 80 on 100 mesh | 9 | 14 | 12 | 13 | 17 | 14 |
| Through 100 on 200 mesh | 6 | 26 | 7 | 28 | 11 | 26 |
| Through 200 mesh | 4 | 40 | 4 | 42 | 5 | 38 |
| Tons per horse-power per day at one passage through machine | 2.30 | | 1.94 | | 2.92 | |
| to pass 100 mesh | 1.31 | | 1.14 | | 1.40 | |
| to pass 200 mesh | 0.83 | | 0.74 | | 0.97 | |
| Pounds metal consumed per ton | Iron worn 3.41<br>Scrapped 0.82<br>Total 4.23 | | Pebbles 1.66 | | Pebbles 1.30 | |

The tendency to discard amalgamation where the gold which would be recovered is saved in another part of the process is not always justified. It is an advantage to recover the gold as soon as possible.[1] Take for example a case where the amalgamable gold is all recovered in the mill concentrate and the concentrate is shipped to a smelter. The shipper loses by leakage of ore in transport, by inclusion of iron in grinding the sample, by losses in assaying and by the extra charges and deductions which the smelter makes on the higher grade material. In the same way losses may be shown where the concentrate is leached by the cyanide process or by the chlorination process.

[1] G. A. James, *Min. and Sci. Press*, Vol. CIV (1912) p. 629; *Journ. Chem Met. and Min. Soc. S. Africa*, Vol. XIII (1912), p. 117.

## Magnetic and Electrostatic Separation

The Ruthenburg magnetic separator has been installed in the Loughborough mill, England, to treat complex tin ores.[1] The old method was to stamp and concentrate on tables. The concentrates containing tin, copper, wolfram and pyrrhotite, were roasted to eliminate sulphur and arsenic and to make the iron porous and of lower specific gravity, and were then treated again on tables to recover the tin.

In the new process the ore is crushed in breaker and rolls to 30 mesh and given a "flash roast" in a gas-fired revolving cylindrical furnace. The roasted ore is cooled and fed to the Ruthenburg magnets which take out all the iron and copper minerals and wolframite and part of the tin. The non-magnetic residue containing the rest of the tin and quartz is easily separated on tables. The magnetic portion may be separated into iron, wolframite, etc., by using magnets of different strengths. The wolframite product goes to market; the copper and tin product is roasted to finish the elimination of arsenic and then smelted into an alloy

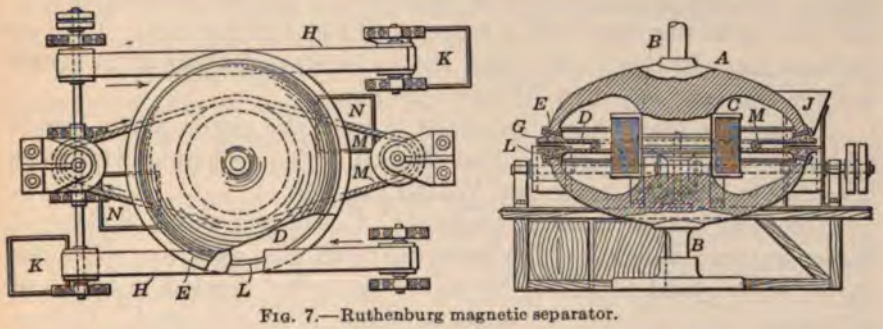



Fig. 7.—Ruthenburg magnetic separator.

of tin and copper. The extraction is 95 per cent. by this method as compared to 65 per cent. by the old method. The method of operation of the magnet is shown in the figure.

The double mushroom magnet *A* is mounted on a vertical spindle *B* running in suitable bearings, and has a central core, around which is wound the exciting coil *C*. The magnetic field is used in the gap at the periphery, the upper pole piece *G* being beveled to concentrate the field, while the lower pole piece *L* is left flat. A channel *D* of non-magnetic material is secured by flanges to the inside of the pole pieces and annular brackets *E* of the same material are bolted to the outside. By means of the belts *H*, the crushed ore is conveyed between the pole pieces; the magnetic particles are attracted and adhere to the upper pole pieces; whence

[1] J. B. Van Brussel, *Eng. and Min. Journ.*, Vol. XCIV (1912), p. 988. M. Ruthenburg, *Met. and Chem. Eng.* Vol. X (1912), p. 411; *Mines and Minerals*, Vol. XXXII (1912), p. 749.

they are swept off by the rope *M* which is driven faster than the mush-room magnet. The magnetic particles fall into a receptacle *N*, while the unattracted particles are carried away by the belts and fall into the receptacles *K*.

The 30-mesh screens are really revolving ring trommels, the rings being spaced a distance apart equivalent to 30 mesh. The rings are V-shaped in sections so as to yield a tapering slot and prevent clogging of the slots.

The increasing amount of pyrite in the Pierrefitte Zinc mill, France (see MINERAL INDUSTRY, Vol. XVII, p. 948) has necessitated the installation of a method of separating the blende-pyrite concentrates.[1]

The material is roasted in two furnaces with a common fore-hearth. Each furnace consists of five superimposed hearths having a central hollow shaft making 5 r.p.m. and carrying two rabbles per hearth. The ore is worked outward on the first hearth, drops to second, is worked inward, drops to third and so on. The cooled ore is screened to remove any coarse lumps which are recrushed, and then goes to the magnetic separator. The cost of the process is $0.60 per ton. The zinc is raised from 27 per cent. to 42 per cent. with a recovery of 91 to 92 per cent. The two furnaces treat 50 tons in 24 hours, the cooler 40 to 50 tons in 24 hours, and the magnetic separator 70 tons in 24 hours.

A magnetic plant[2] has been added to treat the galena pyrite blende middlings at the Wellington mill at Breckenbridge, Colorado, which was described in MINERAL INDUSTRY, Vol. XIX, p. 776.

According to experimental results of C. C. Conover and E. R. Morris[3] the separation of sphalerite from barite can be affected easily and efficiently by the electrostatic process if the mixed ore is first treated in a bath of extremely dilute solution of copper sulphate, dried and sized. Extraction on 20-mesh sized material amounted to 97.8 per cent. of the zinc. The copper consumed is 2.1 lb. of crystallized copper sulphate per ton of ore. The deposited film is believed to be cupric sulphide, and it is formed in one minute sufficient to make the blende a good conductor and effect a satisfactory separation. The copper sulphate bath to change the conductivity of minerals has been used by the Huff Electrostatic Company for some time.

The Huff Electrostatic process has been installed at the Sunnyside mill at Eureka, Colorado,[4] to treat table middlings containing about 0.19 oz. gold per ton, 13.0 oz. silver, 10 per cent. lead, 28 per cent. zinc, 10 per

[1] E. C. Hugon, *Inst. Min. and Met.*, Vol. XXI. (1912), p. 691, *Met. and Chem. Eng.*, Vol. X. (1912), p. 430.
[2] H. C. Parmelee, *Met. and Chem. Eng.*, Vol. X (1912), p. 527; *Min. and Eng. World*, Vol. XXXVII (1912), p. 666.
[3] *Eng. and Min. Journ.*, Vol. XCIV (1912), p. 1089.
[4] F. S. MacGregor, *Min. Sci.*, Vol. LXV (1912), p. 448. W. C. Prosser, *Eng. and Min. Journ.*, Vol. XCIV (1912), p. 105.

cent. iron and 9 per cent. insoluble. The metals are in the form of sulphides. These middlings are dried in a double cylinder rotating dryer and screened in a trommel to remove any pieces coarser than 30 mesh which go back to be recrushed. The Huff machine makes pyrite concentrates, blende tailings, and middlings which are retreated. The finished product assay as follows:

| | Ounces Gold. | Ounces Silver. | Per cent. Lead. | Per cent. Zinc. | Per cent. Copper. | Per cent. Iron. | Per cent. Insoluble. |
|---|---|---|---|---|---|---|---|
| Pyrite | 0.24 | 29.76 | 20.4 | 11.0 | 4.9 | 24.97 | 2.9 |
| Blende | 0.16 | 7.7 | 5.6 | 40.2 | ..... | 5.1 | 9.8 |

## Centrifugal Separation

The possibilities of centrifugal separation for slime have always appealed to the ore dresser but the difficulty has always been in developing an apparatus which would work in practice.

The Gee centrifugal settler[1] is reported to have been developed to a point where it is to be applied in the working of a china clay in Cornwall.

The settler consists of a vertical cylinder revolving at a peripheral speed of 100 to 200 ft. per second. This cylinder has removable lining to which are attached vertical radial vanes extending about half-way from the cylinder to its axis. Pulp fed in at the top has its solid particles thrown out in a cake on the inside of the removable liners while the wall of water escapes through holes in the bottom of the cylinder. When the cake is sufficiently thick the vanes and linings are lifted out and the cake removed.

The slime concentrator for ores has the vanes mounted separately and revolving faster than the cylinder, but in the same direction, the purpose being to cause a washing effect at the point of deposition so that the particles of lower specific gravity are kept in suspension and eventually removed with the effluent water.

The Peck centrifugal machine (See Richard's "Ore Dressing," Vol. II, p. 828) has been improved and is now mounted on a vertical axis (U. S. patents, No. 879893–4, 917120–1–2–3, 981679–80–1–2, 1011077–8, 1012097). Experimental installations have been made by the Anaconda

[1] W. J. Gee, *Royal Society of Arts Journ.*, Jan. 26, 1912, p. 274; *Mines and Methods*, Vol. III (1912), p. 527; *Min. and Eng. World*, Vol. XXXVI (1912), p. 867; *Min. Mag.*, Vol. VI (1912), p. 224; *Eng. Mag.*, Vol. XLIII (1912), p. 89; *Am. Met. Soc.*, Vol. I (1912), p. 122; *Min. Journ.*, Vol. XCVI (1912), p. 111. E. Walker, *Min. and Sci. Press*, Vol. CIV (1912), p. 598. G. T. Vivian, *A. I. M. E. Bulletin* No. 70, Oct. (1912), p. 1103.

Company and the Cananea Consolidated Company but no report has been furnished regarding the success of its work.[1]

## Flotation Processes

The separation of minerals by flotation is finding increasing applications, the processes themselves are being improved and a study of their action is leading to a better knowledge of the fundamental principles of flotation.

Originally applied on a large scale to the solution of a special problem at Broken Hill the use of flotation in its different forms has now spread to include all kinds of sulphide ores in all parts of the world. New installations are reported from Japan. On the American continent the people have been rather slow to appreciate the possibilities of flotation. At the Braden copper mine in Chile the chalcopyrite ore showed a tendency to be lost in the tailings of the wet concentration thus causing a low extraction. The addition of the Minerals Separation process to treat these tailings has resulted in a high extraction. Part of the blende in the zinc ore of the Butte and Superior mine is finely disseminated and here also flotation after wet concentration gives a much higher extraction than wet concentration alone.

These examples indicate the possibilities that exist for the application of flotation for the saving of values now going to waste in the tailings and slimes of wet concentrating mills. We have about gone to the limit in the handling of slimes in the wet way. Elaborate systems for settling slimes and for concentrating the thickened pulp have succeeded in saving only a fraction of the values and in the obtaining of a concentrate of low grade. The fundamental difficulty in handling slimes in the wet way is that the fine particles of heavy mineral lose to a greater or less extent their power to settle in water, or in other words, heavy mineral and light gangue have not sufficient difference in settling power to make an easy separation possible. In fact in very fine sizes the conditions may be reversed and the heavy mineral may not settle as rapidly as the light. It seems natural therefore that a flotation process which acts independently of the specific gravity of minerals and which not only takes advantage of the natural buoyancy of fine sulphides, but also adds thereto, should be the proper process for the treatment of slimes. As time goes on we may find that our elaborate arrangements for concentrating slimes in the wet way have all been wrong, and it may result that in the future it will be found much simpler and more profitable to abandon everthing finer than the ordinary Wilfley table or vanner treatment and substitute there-

[1] Peck Centrifugal Separator, *Met. and Chem. Eng.*, Vol. X (1912), p. 235; *Min. Mag.*, Vol. VI (1912), p. 375; *Eng. and Min. Journ.*, Vol. XCIV (1912), p. 222.

for some form of flotation process. It is barely possible that we may reach the point in wet concentration where slimes are desirable instead of being a bugbear just as in cyanide work slimes, up to within a very few years were avoided as much as possible as offering a difficult problem for satisfactory treatment.

The increasing importance of flotation in ore dressing is indicated by the timely appearance of a book devoted entirely to this subject, written by T. J. Hoover and published by the *Min. and Sci. Press* of San Francisco. It covers the progress in flotation up to the present time.

*Theory of Flotation.*—K. A. Mickle[1] has continued his experimental study of flotation, the previous results of which have already been given in MINERAL INDUSTRY, Vol. XX, p. 831.

The production of froth occurs to a slight extent when pure water is agitated with air. The frothing is increased by the addition of small quantities of certain substances, not only some which are soluble, but also some which are insoluble. One drop of contaminant mixed with 60 c.c. of pure water and agitated with air produced froth in the following descending order: (1) Saponin; (2) turpentine; residual oil from rectification of eucalyptol; (3) refined petrol (0.754); acetic acid; (4) eucalyptol; crude shale oil (0.900); cotton-seed oil; (5) oleic acid; combustion engine oil (0.831); (6) shale residue oil; (7) kerosene; (8) alcohol; oil of wintergreen; naphtha; gasolene; ether; petroleum; sulphuric ether. The froth produced by the substances under (8) was practically no more than that produced by pure water. Frothing occurred in just the same order when the contaminants were increased to 10 c.c. in 60 c.c. of water, and even when the water was entirely absent, but in the latter case the frothing with any one substance was less than when water was present. Some of these substances used in the proportion of one drop to 60 c.c. of water caused an opacity which remained after agitation. The degree of opacity was in the following order: Oil of wintergreen (greatest opacity); turpentine; cotton-seed oil; residual oil from rectification of eucalyptol; machine oil, kerosene; naphtha. Other substances gave no opacity. When 10 c.c. of the substance was added to 60 c.c. of water and agitated with air, after standing for some time, a layer of white emulsion was noticed between the layer of oil and the surface of the water. This was greatest in the case of machine oil and oleic acid, followed by oil of wintergreen, naphtha, kerosene, eucalyptol and turpentine. The other substances showed no emulsion.

Turpentine, gasolene, naphtha, eucalyptol and kerosene spread out in a thin film when one drop was added to water. Oleic acid formed a film

[1] Proceedings *Royal Society Victoria*, Vol. XXIV (N. S.), Part II, 1911; *Aust. Min. Stand.*, April 11; 18, 25, May 2, 1912; *Min. Mag.*, Vol. VII (1912), p. 63; *Met. and Chem. Eng.*, Vol. X (1912), p. 430; *Min. and Sci. Press*, Vol. CV (1912), p. 12; *Eng. and Min. Journ.*, Vol. XCIV (1912) p. 71.

with one drop but a second drop remained as a globule. Cotton-seed oil, machine oil and engine oil did not form a film, but remained in globules. This property depends largely, but not entirely, on the viscosity of the oil.

To show the amount of the oil absorbed by minerals, mixtures of minerals, water, and oil (with and without a small quantity of sulphuric acid) were agitated thoroughly until the character of the resultant product reached a definite standard. The results showed that while there are differences in the degree of attraction between a given sulphide and various oils, or between a given oil and various sulphides, still all sulphides will become attached to all oils in preference to water. With gangue minerals the character of the product varied with different minerals.

The following series of tests were made by agitation in bottles with 200 c.c. water, 5 grm. oil and 0.5 grm. sulphuric acid. With heavy engine oil and 1 grm. of 40-mesh blende, some mineral floated at first, later sank carrying large blobs of oil, oil and blende product non-miscible with solution; excess oil on surface of solution. With 5 grm. results were similar except some oil broke away from sunken blende and rose to surface. With 10 grm. a heavy free-flowing oily magma was formed below the solution; excess of oil still on surface. With 20 and 30 grm. the mass at bottom became more putty like and less oil on surface. With 40 grm. the mass broke up into rounded lumps on agitation and no excess oil on surface. With 80 grm. the mass at the bottom consisted of small coherent aggregations which on violent agitation attached many air bubbles, but would not float. With 120 grm. the aggregations were smaller and less coherent; more tendency to attach air bubbles and to float. Tests with galena and oleic acid gave much the same results as those of blende and engine oil except that the mass at the bottom flowed more freely. Similar tests were made with blende and heavy lubricating oil, copper pyrites and heavy engine oil, galena and kerosene, galena and machine oil, galena and cotton-seed oil, galena and eucalyptus oil containing 80 per cent. phellandrene, and in a general way the same stages were passed through as the proportion of mineral was increased. The lighter oils at any one stage make a less viscous and a less coherent mass, have less free oil on the surface, and require less mineral to arrive at the flotation stage. Tests made in a similar way but using sized galena showed that increasing the size of the particles had much the same effect as increasing the heaviness of the oil in the preceding tests, that is, galena between 30 and 40 mesh still left oil on the surface when 80 grm. of galena had been added, while at 120 mesh no oil was left on the surface when 40 grm. had been added.

For comparison with the foregoing some tests were made omitting the acid. The results were much the same as before except that when

acid was absent the product showed a tendency to attach air bubbles at a lower proportion of oil to mineral and the mass had a more flocculent appearance.

Similar tests on gangue minerals without acid showed that they exhibit less tendency to attach oil than the metallic sulphides. With acidic minerals like quartz the tendency was very weak but the behavior of the more basic minerals like calcite approached that of metallic sulphides. When acid was added the tendency to attach oil was lessened. In tests on mixtures of sulphides and gangue it was noticed that some of the gangue particles were mechanically held by the sulphide aggregates and thus floated to the surface.

Following are the conclusions from all the foregoing tests:

(1) Finely divided sulphides, when suspended in pure water, will adsorb varying amounts of oil. Large proportions of oil tend to form magma, and smaller proportions plastic masses and coherent aggregates. The character of these oily magmas depends upon the amount and character of the oil used. Thick oils give viscous coherent products, and thin oils give less coherent products.

Oily magmas containing considerable proportions of oil will entangle and hold gaseous bubbles with a degree of persistency which depends on the viscosity of the oil. Sulphides carrying about 5 per cent. of adsorbed oil tend to attach gaseous bubbles and this tendency increases as the proportion of oil diminishes until a certain limit is reached, which is 0.5 per cent. or thereabouts.

(2) Adsorption is more pronounced with sulphides than with quartz, feldspar, and most of the acidic rocky minerals, forming the gangue of ores.

(3) Some of the silicates and other gangue-forming minerals will adsorb oils in a manner approaching that of the sulphides, for example; rhodonite, garnet, magnetite and calcite.

(4) Tests on sized minerals show that the amount of oil adsorbed depends upon the extent of surface exposed.

(5) In acidulated solutions, sulphides will adsorb oil in the same manner to form oily magmas, plastic masses and coherent aggregations, as in the case of water and oil without acid. The amount depends on the extent of surface exposed by the minerals, as previously.

(6) Gangue minerals will not adsorb oils to nearly the same extent as when acid is present.

(7) The maximum amount of oil adsorbed by sulphides in a stable manner, when crushed to pass through an 80-mesh sieve is about 10 to 15 per cent. of their weight. This is shown by the absence of excess of oil on the surface in the above tests when the percentage of oil to mineral

was at or near these values. The tendency of plastic magma to break up and form less coherent aggregations at this point also indicates the limit of true adsorption.

With a view of further investigating gas adsorption phenomena, pieces of copper and silver foil were cleaned by boiling in a solution of sodium hydroxide, washing in distilled water and drying, and were then placed in a vacuum flask under reduced pressure (26 in. of mercury) in three liquids as shown in the table.

| | Distilled Water. | Air-free Distilled Water. | Tap Water. |
|---|---|---|---|
| Cleaned foil..... | A few bubbles collected on the foil but the foil did not float. | Very few bubbles formed on the foil; when these were detached no more formed. | Foil floated by buoyancy of bubbles that became attached. |
| Uncleaned foil..... | Many bubbles became attached and foil floated to surface. | A few bubbles formed on the foil on detaching which no more formed. | Same as cleaned foil. |

Tests with cleaned steel needles and wire showed that they would not float on fresh distilled water at first, but would float if the water or metal stood exposed to the air, or if the metal was handled. A solution of carbon dioxide in water showed a much greater attachment of bubbles to uncleaned metal.

To determine amount of gas given off to oiled and unoiled particles, two cubes of galena, one clean and the other greased with vaseline were immersed in carbon dioxide solution. Bubbles grew to a large size and were held more tenaciously but more gas was given off from the unoiled piece, thus showing that oil is an agent by which gas bubbles are more tenaceously attached, but it is the mineral itself which in the first place determines the gas attachment.

Tests on Broken Hill jig tailings which had been washed with sulphuric acid and then with water to remove the acid showed that gas collected only on the sulphide particles. These same tailings unwashed showed gas attachment both on the sulphides and the gangue. This shows that the acid treatment tends to prevent gas attachment to the gangue.

Two flotation products from one of the Broken Hill plants using oleic acid and acidulated solution were placed in bottles and the gas which became disengaged was analyzed and found to contain: (1) Nitrogen, 72 per cent.; oxygen, 2 per cent.; carbon dioxide 26 per cent. (2) Nitrogen, 82 per cent.; oxygen, 2 per cent.; carbon dioxide, 16 per cent. After the product was deprived of all its visible gas some more gas (1.7 c.c.) was obtained by exhaustion in air-free distilled water, which analyzed 58.8 per cent. carbon dioxide; 2.7 per cent. nitrogen and 14.1 per cent. oxygen. By heating to boiling and continuing the exhausting,

an additional 8.9 c.c. of gas was obtained which was nearly all carbon dioxide. A sample from another plant yielded disengaged gas containing 95 per cent. nitrogen, 1 per cent. oxygen and 4 per cent. carbon dioxide. Heating and exhausting as in the other case gave 18.5 c.c. of gas which was almost entirely carbon dioxide. These analyses show that carbon dioxide is more persistently attached to particles of sulphide than is air.

Experiments were next made on exhausting gas from dry minerals under reduced pressure. The detailed results of these tests, which are given in the original paper showed that more gas was obtained from sulphides than from calcite or quartz. The gas was mainly carbon dioxide which could not have been derived from decomposition of carbonates. The results indicate that a concentration or condensation of gas, consisting mainly of carbon dioxide, occurs on the surface of sulphides and to a much less extent on other minerals tested. This gas is held persistently; it does not obey the laws of gaseous diffusion and may therefore be present in liquid form. This is indicated by the fact that it is the more easily condensed gas that is the more persistently attached. The fact that finely divided material in the form of slimes will attach more gas than similar material in a coarser state indicates that the phenomenon is a surface action. It may be akin to the action of charcoal which will absorb large volumes of the more readily condensible gases as carbon dioxide, sulphur dioxide and water. It is known that water vapor will cling most persistently to some surfaces even at high temperatures.

A series of tests was made on Broken Hill ore and tailings to obtain data as to the effect of acid on the flotation product when an oil is used. Tabulated results are given in the original paper and show that: (1) Without the addition of acid the flotation product made by oil contains much gangue material and (2) the addition of acid up to a certain point decreases the amount of gangue in the flotation product.

Up to the present time flotation has been limited almost entirely to separation of sulphides from gangue. In one exception, the Horwood process, blende and galena are separated by giving them a preliminary roast. The blende is unchanged, but the galena has a coating of sulphate formed on its surface which causes it to act like gangue when treated by flotation. Mickle tried some experiments with various chemical solutions for the purpose of preventing the flotation of galena. He obtained best results with solution of ferric chloride which does not effect blende, but does form a white coating of sulphur and lead chloride on the galena. The action is quicker if the solution is hot. Some oxide of iron is sometimes present in the coating if the action of ferric chloride is prolonged. The ferric chloride is reduced to ferrous chloride and can readily be regenerated if required. Some of Mickle's results follow:

Concentrates produced from an acid flotation on Broken Hill tailings ground to pass 80-mesh sieve. Fifty grams taken and kept in suspension for half an hour with 200 c.c. water containing 10 grm. ferric chloride, and allowed to stand 18 hours. Refloated with sulphuric acid and a small amount of oleic acid: Zinc product, 45 grm. floated, 51 per cent. zinc, 6.2 per cent. lead; lead product, 5 grm. not floated, 7.4 per cent. zinc, 47.6 per cent. lead.

Concentrates produced from an acid flotation on Broken Hill slimes, 200 grm. kept in suspension for 6 hours with 300 c.c. of 10 per cent. ferric chloride solution. Refloated with sulphuric acid and a small amount of oleic acid: Zinc product, 169 grm., 51.8 per cent. zinc, 5.3 per cent. lead; lead product, 28 grm., 16.7 per cent. zinc, 38.1 per cent. lead.

Concentrates produced from an acid flotation on another sample of Broken Hill slimes. One hundred grams of concentrates stood for 24 hours with 300 c.c. of 10 per cent. ferric chloride solution. Refloated with sulphuric acid and a small amount of oleic acid: Zinc product, 67 grm., 48.5 per cent. zinc, 8.2 per cent. lead, 25.25 oz. silver per ton; lead product, 31.5 grm., 7.7 per cent. zinc, 46.8 per cent. lead, 13.25 oz. silver.

Crude zinc lead ore from Tasmania: 200 grm. kept in suspension 45 minutes and then let stand with a 3 per cent. solution of ferric chloride. Floated the mixed sulphides with small quantity of sulphuric acid: Zinc product, 77 per cent. by weight, 44.8 per cent. zinc, 5.7 per cent. lead, 22.6 oz. silver; lead product, 33 per cent. by weight, 10.8 per cent. zinc, 41.3 per cent. lead, 9.4 oz. silver.

A study by M. Moldenhauer[1] on the flotation processes leads him to conclude that surface tension is the fundamental cause of this phenomenon. When flotation was first applied by Elmore in a practical way it was known that the minerals which floated were those which were wetted by oils and greases, although only mineral oils appeared to work successfully, oils like linseed oil giving negative results. The first theory was that the particle coated with oil was lifted solely by the buoyant action of the oil, that is, the weight of the particle and its attached oil was less than the weight of an equal volume of water. On this basis it was possible to compute from the specific gravity of the oil and the particle the amount of oil necessary to lift the particle, and it was found that this theory did not suffice to account for all necessary lifting power, and on this basis the amount of oil required was prohibitive. It was also noted that acid water helped the action of flotation. It was therefore decided that surface tension played a large rôle in these processes. Up to the present time about 500 patents have been obtained by Elmore all depending on surface tension of water with respect to minerals and gan-

[1] *Metallurgie*, Vol. IX (1912), p. 72; Revue de Metallurgie Extraits, Vol. IX (1912), p. 457.

gue. The consideration of the factor of surface tension led to the question whether flotation could not occur without oil. This was answered in the affirmative by the introduction of a practical process by Macquisten which would work without oil.

The thickness of a surface film of water on an ore particle cannot be measured directly, but it is capable of being determined indirectly from the law that the angle made by a given liquid in contact with a given solid is a constant and is a measure of the degree that the solid will be wetted. The greater the angle the more is the wetting, and the less the surface tension. These angles have been determined for various substances, but those for all sulphides are so near together that a separation of one sulphide from another by flotation is impossible. A greater difference exists between the sulphide angle and the gangue angle, and in this case separation can take place.

This variation in angles and consequently in surface tension explains how Macquisten was able to work with water alone, but it also shows how the addition of a little oil in the Macquisten process is beneficial owing to the greater surface tension of the oil which decreases the chance that a floating particle of ore may sink. Thus oil is seen to be useful in all flotation work.

Another fact that was established was that flotation of sulphides in water was increased by the addition of salts. Glatzel explained this on the basis that the addition of salts increased the specific gravity of the solution, thus giving it greater lifting power and reducing the amount of oil. This explanation does not cover the case because we have examples of the use of salts for settling slimes and sulphides and, moreover, these slimes and sulphides after being settled may be caused to rise again by heating. The true reason is that salts in solution increase flotation by increasing the surface tension of the solution. In the Potter Delprat process, gas, froth or heat are unnecessary and the action is solely that of increased surface tension.

Coming now to the processes using ascending gas without the oil of Elmore or the agitation of Macquisten, Potter had shown that carbon dioxide formed by the action of acid on carbonates at 65° C. was a practical floating agent, but in his work it was found that this gas when generated from limestone was inefficient, but when generated from carbonates of iron, manganese or zinc, it lifted sulphides satisfactorily. The reason for this was not clear at the time but in the light of the surface tension theory, it appears that with limestone, insoluble calcium sulphate was formed by the acid, but in the other cases soluble sulphates were formed which have the effect of increasing surface tension and promoting flotation. In a modification of the Potter process sodium

acid sulphate is used which reacts on carbonates to form soluble sulphates, sodium hydrate and carbon dioxide. The sodium hydrate is found to add to the action of the carbon dioxide and soluble sulphate in increasing flotation merely by giving added surface tension to the water. It is possible to figure mathematically the weight of gas and the amount of acid necessary for floating a given quantity of mineral and also the amount of carbonate necessary in the ore to produce the gas.

The use of acid appears, therefore, to have its virtue chiefly in increasing the surface tension whether directly or indirectly. Others have claimed that the acid served to remove thin coatings of oxide from the sulphide. De Bavay claimed that it produced colloidal silica and sulphur which were necessary for the process. Others have claimed that its function was to produce carbon dioxide, and others sulphur dioxide. As evidence against these claims we have the facts that it is impossible to find in the solution a trace of metal from the sulphides and in many cases the acid is too weak to give the reactions claimed; moreover, flotation may occur without acid. Weak acid or 2 per cent. sulphur dioxide are just as good, but 5 per cent. sulphur dioxide causes too much agitation, allowing sulphides to sink again. In any process using ascending gases the results are better with oil than without, the function of the oil being to grease the sulphides so that the gas has better action on them.

A thick flowing and viscous oil is preferable. The paraffine content should not be above a certain limit. The oil should separate clean from water, which linseed oil will not do. Heat is useful in all cases since it gives to the oil greater volume, lower specific gravity, less viscosity and greater dispersion.

In the Minerals Separation process which uses oil, acid and gas, it has been found that certain alcohols and their derivatives such as amylalcohol and amylacetate act in the same way as oil. On Broken Hill ore with a temperature limit of 46° C., one part of ore with three or four parts water uses 0.2 to 0.5 per cent. sulphuric acid and 0.01 to 0.002 per cent. amylalcohol or acetate.

All processes which use solutions containing large amounts of reagents in solution lack simplicity because arrangements must be made to recover the reagents before discarding the gangue. Processes like Macquisten and Elmore which work at a low temperature do not act well on the finest particles. Where clayey ores are handled the clay tends to coat the fine sulphides and prevent their recovery, or if the clay is washed out then some of the finest sulphides are also washed away.

In connection with the theory of flotation W. A. C. Pape[1] raises the

[1] *Met. and Chem. Eng.*, Vol. X (1912), p. 392.

question why many metals and other substances when in the molten condition are able to support on their surfaces the solid metal or other substance even though it is heavier than the liquid.

*Development of Flotation.*—Dr. L. Herwegen[1] has contributed a very complete article on the development of flotation in ore dressing. Lack of space prevents a full abstract here.

The flotation processes may be divided into two classes: I. Processes based on the rising power of solids in liquids. II. Processes based upon the surface tension of liquids and the resistance connected with it. Class I may be subdivided into four groups: (*a*) Those based on the power naturally inherent in certain minerals of rising in liquids of higher specific gravity—The Humboldt process. (*b*) Those based on the artificially increased tendency to rise conferred upon certain minerals by their capacity of adhesion to certain gases—the Potter, Delprat, Broken Hill Proprietary Co., De Bavay and Sutton. (*c*) Those based on the artificially increased tendency to rise conferred on certain minerals by their capacity of adhesion to oils as well as to gases—the Leuschner, Sigge, Hoover, Sulman and Picard and Cattermole. (*d*) Those based on the artifically increased tendency to rise conferred on certain minerals by their capacity of adhesion to oils assisted by a vacuum—the Elmore process. The second class may be divided into two groups: (*e*) Processes based solely upon resistance of the smooth surface of a liquid—the Macquisten, Brackelsberg and Jeffrey processes. (*f*) Processes based on the increased resistance inherent to emulsion foams—the Minerals Separation process.

The processes in group (*c*), using oil and gas, give the best results and are the most used to-day. The steps involved are the thorough mixing of the fine ore, usually dry, with oil followed by a discharge of the mixture into water where the separation of sulphides and gangue takes place. The water may or may not be gently stirred, but the best results have been obtained in still water. The Leuschner process used at Friedrichssegen makes a good separation, but at the expense of considerable sulphuric acid—40 to 60 kilos per ton costing $2.40 per 100 kilos. In general where the gangue contains carbonates as at Friedrichssegen the acid necessary to produce sufficient gas or to clean the gangue particles from oil is large, amounting to 30 to 40 kilos per ton on an ore containing 29 per cent. carbonates.

The Cattermole is considered to be one of the best flotation processes. In its improved form using different strong alkaline emulsifiers which modify the adhesive power of oil for different sulphides, it has been

[1] *Gluckauf*, Vol. XLVIII (1912), p. 1185, 1231; *Montanist Rundschau*, Sept. 15, 1912, p. 965; *Metall. und Erz*, Vol. X (1912), p. 88; *Eng. and Min. Journ.*, Vol. XCIV (1912), p. 500.

able in a series of three treatments to take out blende in the first, pyrite in the second, and galena in the third. The fault with the process is that considerable oil remains attached to the ore which can be removed only in a vacuum. Elmore has a fundamental patent on the use of vacuum and therefore the Cattermole process will not come into its own until the Elmore patent expires. A further advantage of Cattermole over Elmore lies in the smaller quantity of oil required by the former. On the other hand the Elmore requires less oil than the Leuschner, Hoover and others. The Elmore is hampered in turn by its inability to use emulsion which has been patented by the Minerals Separation Company in almost all civilized countries. Elmore is thus forced to introduce the oil into a thicker pulp and to do the mixing in simple horizontal cylinders with stirrers running at low speed.

The Minerals Separation Process is the emulsion process of group (*f*), the sulphides being floated in a froth formed by the use of a small quantity of oil or other hydro-carbon with water, air, ore and acid. The apparatus consists of a series of six deep stirring compartments about 27×27 in. in section connected with one another by slots near the bottom. The oil, acid and ore through 60 mesh fed to the first compartment pass successively through the other five. Also each compartment has a slot near the bottom connecting it to a spitzkasten, and the bottom of each spitzkasten except the last has a connection with the bottom of the next stirring compartment. The stirrers act like centrifugal pumps creating the necessary suction to move the pulp from the bottom of the spitzkasten into the stirring compartment. From the first compartment some of the agitated mass is forced directly into the second compartment while some of it is thrown by the stirrer out into the first spitzkasten where the water is quiet and the sulphides rise to the surface in a froth and go into the overflow. Whatever settles in the first spitzkasten is sucked through the connecting tube up through the bottom of the second stirring compartment where the same operation is repeated and so on through the six compartments. The spigot of the sixth spitzkasten is clean waste, and goes to a settling tank from which the liquid is pumped back to be used again. The concentrates go to filter tanks where the liquid is recovered and pumped back. Mixed concentrates of galena and blende may be separated on tables into galena, middlings and blende and the middlings may be reground and reconcentrated. This process works well in practice and gives extractions between 85 and 95 per cent. A 100-ton unit consists of about 8 stirring compartments and 6 to 8 spitzkasten. The oil consumption is about 0.5 kilo per ton of ore. The oil is not recovered from the concentrates.

A complete plant to crush and treat 100 tons of hard ore in 11 hours

costs about $23,000, requires about 100 h.p., and the cost of treatment is about 80 cents per ton. Tests indicate that this process can make a fairly good separation on some carbonate ores as well as on sulphides.

The original article contains detailed descriptions of the various flotation processes and also detailed figures on costs and results with the Elmore and Minerals Separation processes.

*Progress during the Year.*—The patent litigation between the De Bavay and Potter processes on the one hand, and the Minerals Separation process on the other has been settled for Australia by the formation of a new company in which the Minerals Separation has 55 per cent. interest and the DeBavay, which controls the Potter, has 45 per cent. For other parts of the world the old Minerals Separation Company acquires the rights to the DeBavay and Potter patents.[1]

The Murex magnetic flotation process at Cordoba, Spain, is reported to have treated during the year 9455 tons of copper sulphide middlings from the wet concentrators and to have recovered 936 tons of concentrates.[2] The middlings contained 1.47 per cent. copper and the concentrates 12.2 per cent. copper. The magnetite is not eliminated as it is desired in the smelting. The oil used is a thick coal tar product. It is proposed to extend the Murex treatment to the wet concentrator fine tailings and slimes which contain 1.17 per cent. and 1.53 per cent. copper respectively.

The Murex process is also reported to be doing satisfactory work at Grund.[3]

The Leuschner flotation process[4] is the name given to a combined oil and acid flotation method used at the Friedrichssegen and Ludwigseck mines in Germany. Gas for flotation is generated from carbonates which are added in cases where the ore does not contain them in sufficient quantity. At Friedrichssegen this process has superseded Wetherill magnets on an ore containing blende, spathic iron, quartz and graywacke. The material ranges from 1 mm. to 0 in size and averages 10 to 15 per cent. zinc. Concentrates assay 47 to 50 per cent. zinc and tailings 0.3 per cent. The extraction is from 90 to 97 per cent. of the zinc. The acid used is 60 degree Glover acid and the bath has a specific gravity of 1 to 2° Baumé at a temperature of 60 to 80° C. The acid consumption per ton of ore is 40 to 60 kilos and the oil 4 to 6 kilos. The total cost is $0.96 to $1.42 per ton. The cost of a plant to treat 10 to 15 tons in 10 hours is $1250 to $1500 and the plant requires 2 to 3 h.p.

[1] *Min. Mag.* Vol. VI (1912), p. 241.
[2] *Min. and Sci. Press*, Vol. CIV (1912), p. 466.
[3] *Zeitschrift für das Berg. Hütten und Salinenwesen*, Vol. LX (1912), p. 129.
[4] Holtmann, *Glückauf*, Vol. XLVIII (1912), p. 188; *Bulletin de la Société de L' Industrie Minerale*, (Series V, Vol. II (1912), p. 352; *Min. Journ.*, Vol. XCVII (1912), p. 402, *Min. and Eng. World*, XXXVII (1912), p. 480; *Min. Mag.*, Vol. VI (1912), p. 377; *Eng. and Min. Journ.*, Vol. XCIII (1912), p. 924, Vol. XCIV (1912), p. 581.

At the Ludwigseck mine the ore is similar except that it also contains galena. The gale and the zinky middlings are subjected to flota

The method of operation is along the sar flotation processes. The acid and oil are ad in a launder to the flotation vats. Here the out the spigot while the sulphides overflow they are separated from the liquid which is again. Tests of the process show that it y 90 per cent. in most cases on any kind of flotation processes it cannot make a separatio one another.

Henry E. Wood[1] has developed and patent apparatus all based on the surface tension o all effecting the separation of sulphides from ing the dry crushed ore upon a swiftly movin retarding the current to allow the gangue to mesh may be treated. The three types differ ratus used to obtain the desired separation.

Copper sulphide ore, if allowed to stand af steam heat after grinding, does not float nearly ore. In the case of other sulphides, galena, r etc., standing or heating has no harmful minerals, including magnetic blende, will sink. for flotation by ball mills or rolls which avoi into impalpable dust.

A great many tests were made in develop The results showed that the apparatus, eithe with other apparatus such as Wilfley tables of doing high grade work not only on ord in recovering fine sulphides from gold ore gangue, molybdenite, graphite, gold, platir gangue.

The table on the following page illustra results obtained.

The Minerals Separation process has be copper mine near Cooma, New South Wa sulphides of copper and iron associated wit

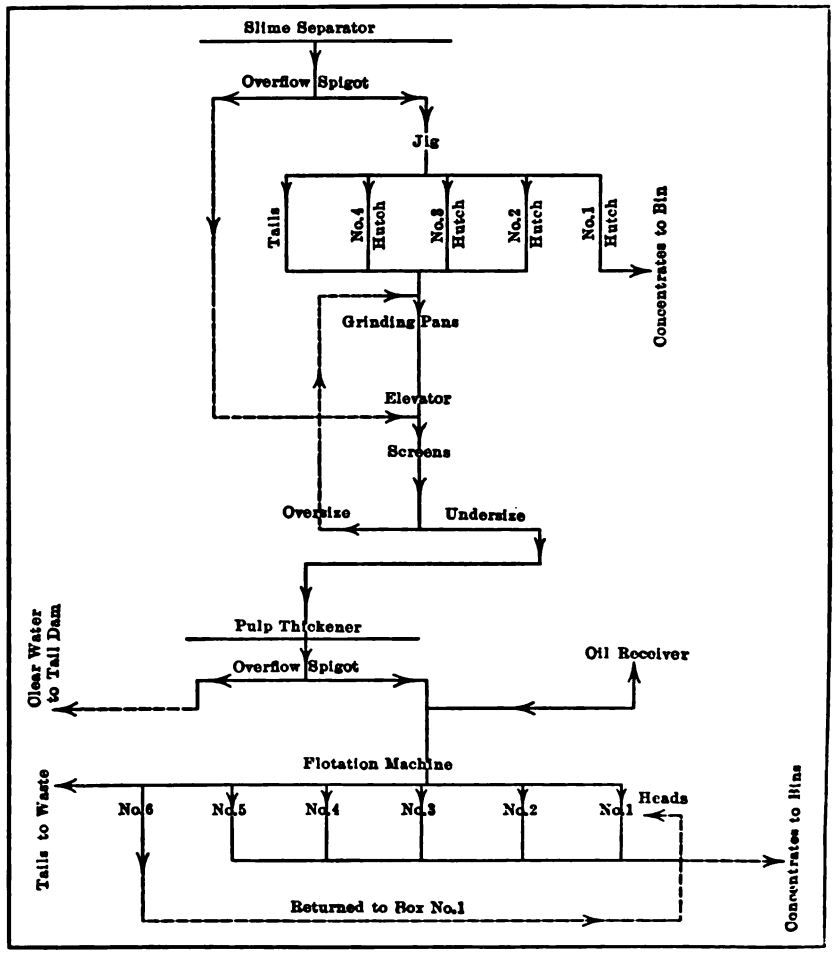
[1] *A. I. M. E., Bulletin* No. 71, Nov., 1912, p. 1227; *Min. S* H. E. Parmelee, *Met. and Chem. Eng.*, Vol. X (1912), p. 132; *Eng.* p. 227.

[2] J. W. Ashcroft, J. M. M. Bulletin 91, *Canadian Min. Journ and Min. Journ.*, Vol. XCIV (1912), pp. 1071, 1085; *Met. and Min. Journ.*, Vol. XCIX (1912), p. 1082; *Mines and Methods*, Vo

| Locality. | Size, Mesh. | Assay of Ore. | Concentration. | Assay of Flotation, Concentrates. | Recovery by Flotation, (Concentrate). | Total Recovery. |
|---|---|---|---|---|---|---|
| Copper Ores. | | Per cent. Copper. | Tons into 1. | Per cent. | Per cent. | Per cent. |
| Canada, chalcopyrite | 40 | 2.60 | 8.25 | 17.10 | 79.72 | 94.48 |
| Mexico | 40 | 5.80 | 3.28 | 13.20 | 69.40 | 88.45 |
| Colorado | 40 | 1.42 | 5.97 | 5.40 | 63.75 | 83.29 |
| Colorado | 40 | 2.60 | 4.75 | 12.25 | 96.28 | 98.45 |
| Canada | 40 | 2.75 | 9.38 | 13.45 | 52.15 | 86.05 |
| Colorado | 40 | 2.50 | 7.04 | 15.00 | 71.59 | 88.35 |
| Nevada chalcopyrite and garnet | 40 | 3.85 | 9.80 | 15.45 | 40.94 | 91.21 |
| Arizona tailings | 40 | 0.47 | 23.25 | 4.80 | 43.95 | 74.16 |
| Mexico | 40 | 15.20 | 2.14 | 26.50 | 81.48 | 89.01 |
| Montana | 40 | 1.90 | ..... | 11.40 | 42.92 | 90.45 |
| Colorado | 40 | 8.28 | ..... | 21.60 | 52.71 | 91.57 |
| Gold Ores. | | Ounces per Ton. | | Ounces per Ton. | | |
| Colorado | 40 | 0.26 | 26.66 | 6.32 | 91.19 | 91.19 |
| Mexico | 40 | 0.42 | 5.83 | 1.00 | 40.98 | 94.41 |
| Colorado | 40 | 0.66 | 5.97 | 1.42 | 36.04 | 86.48 |
| Colorado | 40 | 3.50 | 4.75 | 4.86 | 29.24 | 89.62 |
| California arsenical pyrite | 40 | 90.96 | 14.59 | 311.00 | 23.43 | 94.52 |
| Arizona | 40 | 0.12 | 23.25 | 0.98 | 35.13 | 80.12 |
| Silver Ores. | | | | | | |
| New Mexico | 40 | 15.90 | 23.25 | 184.90 | 50.01 | 90.01 |
| Mexico | 40 | 95.60 | 5.83 | 340.90 | 61.11 | 86.26 |
| Colorado | 40 | 3.00 | 5.97 | 10.60 | 59.12 | 88.61 |
| Colorado | 40 | 12.96 | 4.75 | 43.30 | 70.34 | 84.65 |
| Lead Ores. | | Per cent. Lead. | | Per cent. | | |
| Colorado | 40 | 12.20 | 11.11 | 54.00 | 39.85 | 90.86 |
| Colorado Barite | 40 | 16.50 | 6.06 | 41.60 | 41.60 | 95.82 |
| Canada | 40 | 19.70 | 5.35 | 59.60 | 56.55 | 79.44 |
| Mexico | 40 | 5.60 | 5.83 | 16.90 | 51.77 | 89.65 |

gangue. After removing the high-grade shipping ore by hand picking, the residue going to the mill contained about 6.5 per cent. iron, 4.7 per cent. copper, 5.2 per cent. sulphur, 3.4 per cent. lime and 79.4 per cent. insoluble. The original method of treatment was to crush in rock breaker and rolls and jig on a May jig. The jig concentrates went to smelter, the tailings to waste and the middlings were reground in a ball mill, classified and separated on Wilfley and Card tables and a Frue Vanner into concentrates and tailings. This method recovered about 74 per cent. of the copper in a concentrate carrying 19 to 20 per cent. copper. The process as modified for flotation is shown in the tree. The flotation apparatus is shown in figure 8. Each stirring compartment is 16 in. square. It will be noted that in this apparatus there are no direct connections between the separate stirring compartments. No acid is used and the operation goes on at ordinary temperature. The oil is a crude eucalyptus oil containing a large percentage of phellandrene and costing 17 cents per pound at the mine. The grinding pans are two 8-ft. Forwood-Down pans driven at 30 r.p.m.

In the preliminary testing to determine the best mill scheme some troubles were met with. The froth was found to be too thin on the later boxes due to the decreasing amount of mineral to be floated as the pulp passed from the first box to the last. This was remedied by re-




Tree of Kyloe mill.

ducing the surface area of the boxes by means of "crowding boards." No. 1 box is reduced to 11.5 in. wide and No. 5 to 4.5 in. while No. 6 has a water-tight bulkhead narrowing the surface to 4 in. The quality of the concentrate was found to be poorer in the later boxes as follows:

| | Per cent. Copper. | Per cent. Silica. |
|---|---|---|
| No. 1 overflow..... | 27.2 | 21.2 |
| No. 2 overflow..... | 24.1 | 41.5 |
| No. 3 overflow..... | 22.3 | 59.6 |
| No. 4 overflow..... | 15.6 | 61.0 |
| No. 5 overflow..... | 14.3 | 60.7 |
| No. 6 overflow..... | 9.4 | 68.7 |

For this reason the last overflow is returned to No. 1 box. Iron liners were i stalled in the stirring compartments to take the wear. Originally the grinding pans had a classifying discharge, but this gave too much coarse material and poor results as shown in the table, and

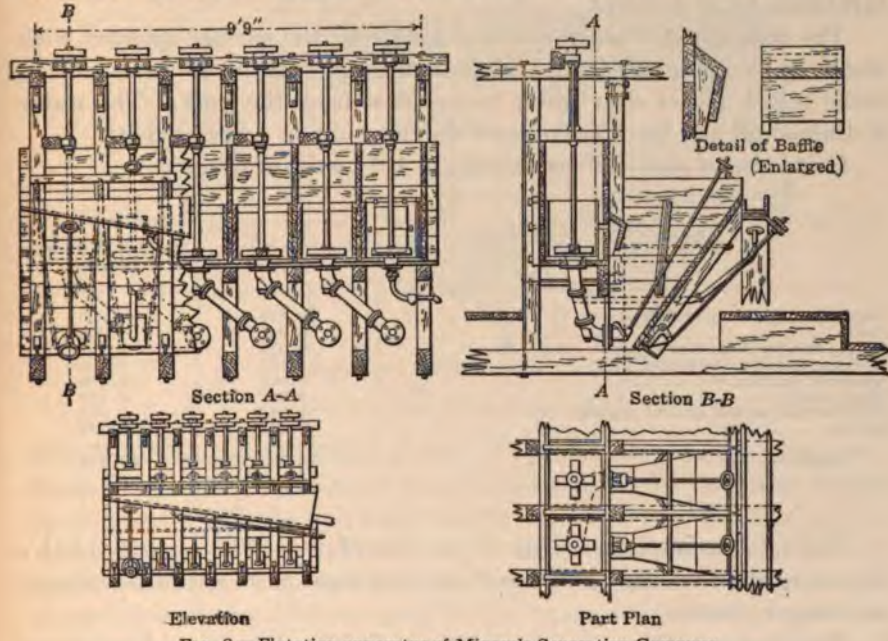



FIG. 8.—Flotation apparatus of Minerals Separation Company.

therefore revolving screens 600 mesh with apertures 0.0268 in., were installed with resultant increase in extraction from 61.8 per cent. up to 76.3 per cent.

| | Feed. | | Concentrate. | | Tailings. | |
|---|---|---|---|---|---|---|
| | Per cent. Weight. | Per cent. Copper | Per cent. Weight. | Per cent. Copper. | Per cent. Weight. | Per cent. Copper. |
| *On 20 mesh ..... | 1.52 | 2.20 | 0.18 | 17.5 | 1.85 | 2.0 |
| Through 20 on 40 mesh..... | 13.12 | 1.20 | 0.30 | 17.0 | 17.53 | 1.2 |
| Through 40 on 60 mesh..... | 15.10 | 0.80 | 0.31 | 18.5 | 20.77 | 0.7 |
| Through 60 on 80 mesh..... | 3.55 | 1.15 | 0.52 | 24.7 | 6.10 | 0.6 |
| Through 80 on 100 mesh..... | 22.50 | 1.40 | 7.42 | 53.6 | 21.40 | 0.6 |
| Through 100 on 130 mesh.... | 3.62 | 3.80 | 1.55 | 21.2 | 4.20 | 0.5 |
| Through 130 mesh..... | 40.40 | 5.45 | 89.60 | 23.75 | 28.00 | 1.2 |

Poor results were obtained where the ore was too clayey even reaching the point where practically no concentration took place. Tests showed that the quality of the work began to fall off when the feed contained more than 40 per cent. finer than 130 mesh. Best results were obtained with 29 to 30 per cent. finer than 130 mesh. A week's run of flotation apparatus under good conditions showed: Feed 3.6 per cent. copper; concentrates 24.4 per cent. copper; tailings 0.79 per cent. copper; extraction 79.6 per cent. The figures for the entire mill from July 29, 1911, to Jan. 27, 1912, were: Ore treated, 7855 tons assaying 5.24 per cent. copper; concentrates 1562 tons assaying 22.65 per cent. copper; extraction 86.36 per cent.

The concentrates are run into a tank and the surface sprayed with water to break up the froth and allow the concentrates to settle while a baffle board allows clear water to overflow from the tank. The water is drained off and the concentrates shoveled out to a drying floor.

Costs over a period of six months in 1911 were as follows:

| | Per Ton of Ore Milled. | Per Ton of Residue Treated. |
|---|---|---|
| Regrinding, screening and flotation | $0.316 | $0.470 |
| Power | 0.947 | 0.069 |
| Drying and handling concentrates | 0.077 | 0.115 |
| Maintenance and renewal | 0.134 | 0.198 |
| Assaying, lighting, etc | 0.046 | 0.069 |
| Water supply | 0.069 | 0.103 |
| Superintendence and general expense | 0.042 | 0.066 |
| Royalty | 0.121 | 0.182 |
| Total cost | $0.752 | $1.272 |

The oil consumption is 0.65 lb. per ton of ore. The capacity of this flotation plant is only 60 tons per day and these costs would be reduced in a larger plant.

The best conditions for operation of flotation are considered to be as follows: The particles must be clean and free from oxidation. The gangue must not be so clayey as to form slime which will float the sulphide particles or will form too large a proportion of the froth. The material to be treated should be ground as evenly as possible, the best size being determined for each individual ore. The feed and speed of the stirrer and the thickness of the pulp must be correctly proportioned and kept as even as possible. The amount of sulphides in the ore is important. At Kyloe it is 10 per cent. of the weight of the ore. The quality of the water according to its hardness and chemical constituents necessitates proper adjustment of the process. Grinding machines should not be used which produce too much slime.

The Hyde flotation process used at the Butte & Superior mill[1] is described in U. S. patent No. 1922085 as follows: The ore after crushing is mixed with acid before thickening in a tank *A*, fig. 9. It has been found that adding the acid in advance cuts down the amount required and promotes the settlement of colloidal material which may be further aided, if necessary, by adding copperas, alum, or other coagulant. The pulp is heated and oil added before it enters the tank *B* where the whole mass is agitated. A float concentrate is then taken off and the gangue

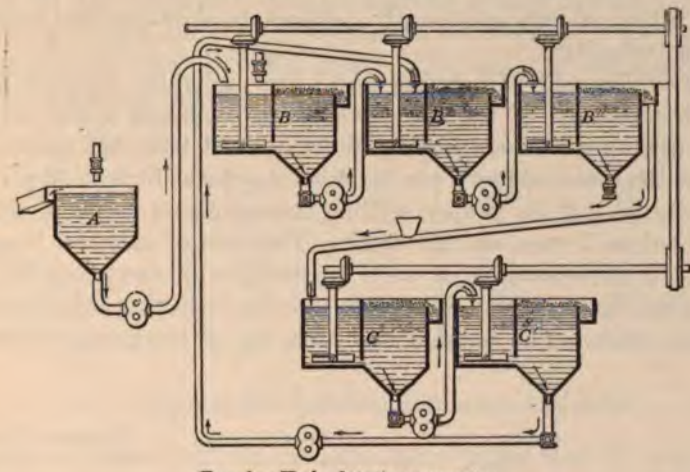



FIG. 9.—Hyde flotation apparatus.

goes in succession to tanks *B'* and *B''* where the process is repeated. From *B''* the gangue is discharged as final tailing. There is considerable gangue mixed with the first concentrates from *B*, *B'* and *B''*, so that they are all recleaned in two tanks *C* and *C'*, the concentrates from which are final products while the tailings from *C'* are sent back to *B'*. Live steam is used to heat the thickened pulp in the treatment tanks to expand the gas bubbles and to facilitate the coating of the sulphides with the oil used.

## SEPARATION BY DECREPITATION

Henry E. Wood reports two cases of successful use of decrepitation by heat.[2]

A plant for separating blende from barite by decrepitation is reported to be in successful operation at the Tahoma mine, Missouri.[3]

[1] *Eng. and Min. Journ.*, Vol. XCIII (1912), p. 1068; *Min. Mag.*, Vol. VII (1912), p. 64; *Met. and Chem. Eng.*, Vol. X (1912), p. 426; *Min. and Sci. Press*, Vol. CIV (1912), p. 893; *Mines and Minerals*, Vol. XXXIII (1912), p. 160.

[2] H. E. Wood, *Eng. and Min. Journ.*, Vol. XCIII (1912), p. 1184; *Metall und Erz*, Vol. X (1912), p. 18.

[3] F. C. Bryant, *Eng. and Min. Journ.*, Vol. XCIII (1912), pp. 929, 1120; *Min. Mag.*, Vol. VI (1912), p. 455.

## Accessory Apparatus

*Conveyors and Elevators.*—Mr. L. DeG. Moss has contributed a very comprehensive paper on different forms of conveyors including bucket conveyors, flight conveyors, reciprocating conveyors and belt conveyors.[1]

In belt conveyors the largest item of cost and upkeep is the belt itself.[2]

To deliver the feed at the same velocity as the belt it should come down an incline of sufficient length and slope to allow the feed to acquire the desired velocity.[3]

*Losses in Drying.*[4]—In drying ores losses occur by abrasion and in dust in the passage of the ore through the common types of either tower or cylindrical dryers having direct contact with hot gases. The amount of the material lost from the drier may be as high as 10 per cent. of the material, but by proper settling arrangements much of this can be saved before it goes out the stack. This loss of material is accompanied by a corresponding or even greater loss of metal content. In one case a lead ore was dried in a revolving cylinder having a dust chamber and smoke stack. The weights and assaying of the products were as follows:

| Products. | Weight, Per Cent. | Assay. | | Percentage of total | |
|---|---|---|---|---|---|
| | | Per Cent. Lead. | Ounces Silver per Ton. | Lead. | Silver. |
| Total feed | 100.0 | 10.35 | 9.68 | 100.0 | 100.0 |
| Dry discharge | 96.2 | 9.77 | 9.34 | 90.7 | 95.40 |
| Settled in chamber | 1.77 | 35.30 | 10.30 | 6.04 | 1.94 |
| Settled in stack | 0.76 | 18.50 | 8.60 | 1.36 | 0.69 |
| Loss in gases | 1.27 | 14.30 | 15.20 | 1.75 | 2.04 |

The abrasion which occurs in a cylindrical dryer is shown by the following example:

| | Feed. | Discharge. |
|---|---|---|
| Through 2 in. on 0.25 in | 83.7 per cent. | 74.4 per cent. |
| Through 0.25 in. on 16 mesh | 16.3 per cent. | 13.8 per cent. |
| Through 16 mesh | 0 per cent. | 12.3 per cent. |

[1] *Columbia School of Mines Quart.*, Vol. XXXIII (1912), pp. 136, 233; *Met. and Chem. Eng.*, Vol X (1912), p. 347.

[2] R. Trautschold, *Iron Age*, Vol. XC (1912), p. 26; *Min. and Sci. Press*, Vol. XC, (1912), p. 628.

[3] C. M. Avery, *Eng. and Min. Journ.*, Vol. XCIII (1912), p. 1121.

[4] C. F. Dietz and D. V. Keedy, *A. I. M. E., Bulletin* No. 67, July, 1912, p. 717; *Min. and Eng. World*, Vol. XXXVI (1912), pp. 993, 1045; *Min. Mag.*, Vol. VII (1912), p. 226; *Journ. Chem. Met. and Min. Soc., South Africa*, Vol. XIII (1912), p 274: *Mining Science*, Vol. LXVI (1912), pp. 168, 186, 217.

The material below 16 mesh in the discharge ranged all the way down to 200 mesh and finer. Abrasion is greater on friable sulphides than on gangue.

The best installation to entirely avoid dust losses in dry work is one having all the apparatus tightly housed and connected to suction fans which deliver to a centrifugal dust collector. Some dust will escape the dust collector if run dry, but if it is supplied with steam jets and water spray, all the dust is scrubbed from the air. A test run using 7000 lb. of ore was made with such an installation in a dry crushing zinc mill and it was found that the dust formed amounted to 1139 lb. practically all of which was finer than 125 mesh. The weights and analyses of the products were as follows:

| | Pounds Weight. | Per Cent. Weight. | Per Cent. Zinc. | Pounds Zinc. | Per Cent. of total Zinc. |
|---|---|---|---|---|---|
| Crude ore | 7000 | 100.0 | 19.01 | 1330.7 | 100.0 |
| Not dusted | 5861 | 83.7 | 18.4 | 1077.5 | 81.0 |
| Vacuum box dust | 601 | 8.6 | 24.3 | 146.0 | 10.93 |
| Suction pipes dust | 24 | 0.4 | 19.23 | 4.62 | 0.35 |
| Collector slime | 514 | 7.3 | 20.15 | 102.9 | 7.73 |

## Principles, Theory and General Ideas

*Slime.*—Some light on the definition of slime is given in some experiments by A. D. Hall contained in his book entitled "The Soil." He has found that pure quartz in a very finely divided condition possesses all the properties of clay and takes therefore the position that the dividing line between sand and slime is an arbitrary one which he is inclined to set at 0.005 mm.[1]

*Efficiency in Concentration.*—In working for highest efficiency in concentration the millman should not lose sight of the fact that this may not mean the greatest ultimate recovery or profit owing to the costs and deductions that occur in the treatment of the concentrate.[2] Take for example the Sulphide Corporation which reports that the lead plant treated 226,768 tons of ore averaging 16.3 per cent. lead, 17.3 per cent. zinc and 11.1 oz. silver per ton and produced 43,446 tons of lead concentrate assaying 61.3 per cent. lead, 8.8 per cent. zinc, and 28.1 oz. silver. The residue was treated in the zinc plant and yielded 70,606 tons of zinc concentrate averaging 42.7 per cent. zinc, 10.9 per cent. lead, and 14.7 oz. silver. The metal recoveries in the two plants were 93.2 per cent. of the lead, 87.8 per cent. of the zinc and 90.2 per cent. of the silver. In smelting

[1] P. C. K. O'Brien, *Am. Met. Soc.*, Vol. I (1912), p. 66; *Journ. Chem. Met. and Min. Soc., South Africa*, Vol. XII (1912), p. 527.
[2] *Min. Mag.*, Vol. VI (1912), p. 253.

the lead concentrate there is no deduction for lead and silver but no zinc is paid for. The zinc concentrate is paid full market price for zinc content less 8 units, but lead is paid only $0.24 per unit with deduction of 8 units, and silver $0.24 per ounce with deduction of 5 oz. The deductions and final recoveries on the above basis are given in the following table:

| | Lead, Tons. | Zinc, Tons. | Silver, Ounces. |
|---|---|---|---|
| Metal contents of ore | 36,890 | 39,132 | 2,512,354 |
| Loss in concentration | 2,508 | 4,774 | 246,210 |
| Not paid for in lead concentrates | ..... | 3,823 | ..... |
| Not paid for in zinc concentrates | 6,919 | 5,648 | 734,202 |
| Total lost to company | 9,427 | 14,245 | 980,512 |
| "Paid for" recov ry | 27,463 | 24,887 | 1,531,842 |
| Percentage of recovery in concentration | 93.2 | 87.8 | 90.2 |
| Percentage of "paid for" recovery | 47.5 | 63.6 | 60.9 |

A study of economic efficiency in lead concentration has been made by R. S. Handy[1] on a 6-ft. Frue vanner in the Bunker Hill & Sullivan mill. Vanner feed was all through 200 mesh, dilution 1 part solids to 7.8 parts water, wash water, 3.57 gal. per minute, speed 200 r. p. m., slope 1/4 in. per foot. The belt travel was varied each day with the results shown in the table. All other adjustments were unchanged.

| Belt Travel, Feet per Minute. | Tons Feed per 24 Hrs. | Assay Feed per Cent. Lead. | Tons Lead in Feed per 24 Hrs. | Tons Conc. per 24 Hours. | Assay Conc. per Cent. Lead. | Tons Lead in Conc. per 24 Hrs. | Per Cent. Extraction, Lead. | Per Cent. Extraction, Economic. | Ratio, Lead to Economic Extraction. |
|---|---|---|---|---|---|---|---|---|---|
| 2.5 | 4.94 | 8.72 | 0.430 | 0.155 | 63.8 | 0.099 | 23.1 | 8.7 | 0.376 |
| 2.7 | 6.46 | 8.31 | 0.537 | 0.187 | 66.9 | 0.125 | 23.3 | 9.7 | 0.416 |
| 3.0 | 5.89 | 11.07 | 0.652 | 0.247 | 71.5 | 0.176 | 26.9 | 16.5 | 0.613 |
| 3.5 | 5.70 | 11.18 | 0.638 | 0.292 | 64.2 | 0.187 | 29.3 | 17.1 | 0.583 |
| 3.7 | 5.46 | 10.59 | 0.573 | 0.367 | 61.2 | 0.225 | 39.2 | 22.3 | 0.569 |
| 3.9 | 6.58 | 9.30 | 0.612 | 0.507 | 56.0 | 0.284 | 46.4 | 28.6 | 0.616 |
| 4.1 | 6.70 | 9.61 | 0.644 | 0.600 | 45.0 | 0.270 | 41.9 | 22.0 | 0.525 |
| 4.3 | 6.06 | 9.63 | 0.583 | 0.498 | 47.2 | 0.235 | 40.3 | 21.4 | 0.531 |
| 4.5 | 6.94 | 8.81 | 0.611 | 0.887 | 29.0 | 0.257 | 42.1 | 17.4 | 0.413 |
| 4.7 | 7.04 | 9.53 | 0.671 | 1.180 | 24.5 | 0.289 | 43.0 | 15.6 | 0.362 |
| 5.0 | 4.96 | 8.69 | 0.431 | 1.040 | 19.0 | 0.197 | 45.7 | 12.4 | 0.271 |

*New Principle.*—Some experimental work has been done on a new method of separating ores making use of a foam.[2] The results are promising and the separation of minerals of approximately the same specific gravity is reported to have been accomplished successfully.

*Graphical Results.*—A graphical method of showing results of tests or of mill work has been described by H. K. Picard.[3] On a sheet of

[1] *Mines and Minerals*, Vol. XXXIII (1912), p. 211.
[2] R. Jaffe, *Metall und Erz*, Vol. X (1912), p. 76.
[3] *Inst. Min. and Met.*, Vol. XXI (1912), p. 424; *Min. Sci.*, Vol. LXV (1912), p. 308; *Min. and Eng. World*, Vol. XXXVI (1912), p. 810; *Eng. and Min. Journ.*, Vol. XCIII, (1912), p. 639.

cross-section paper tonnages of every product are shown by proportional areas, and the proportion of valuable mineral and waste in each product are shown by suitable cross hatching or shading.

*Treatment of Middlings.*—Caetani calls the Wilfley table middling a "counter classified" product.[1] He gives some results of classification at the Tomboy mill, Colorado, on a galena-pyrite-blende-quartz ore.

| | Weight Per Cent. | Zinc Per Cent. | Iron Per Cent. | Insouble Per Cent. |
|---|---|---|---|---|
| Coarse Wilfley middlings, | | | | |
| Feed to classifier | 100.0 | 23.70 | 8.10 | 34.70 |
| Classifier spigot | 91.0 | 25.70 | 8.60 | 32.60 |
| Classifier overflow | 9.0 | 3.85 | 3.50 | 77.80 |
| Sand Wilfley middlings, | | | | |
| Feed to classifier | 100.0 | 27.50 | 11.20 | 22.70 |
| Classfier spigot | 78.6 | 33.60 | 12.50 | 12.20 |
| Classifier overflow | 21.4 | 12.90 | 6.00 | 55.20 |
| Fine Wilfley middlings, | | | | |
| Feed to classifier | 100.0 | 25.90 | 12.50 | 21.90 |
| Classifier spigot | 78.0 | 28.40 | 13.80 | 17.30 |
| Classifier overflow | 22.0 | 18.10 | 8.30 | 40.90 |

The spigot product may be rich enough to ship direct or it may need further table treatment to yield concentrates and a residue of included grains to be reground. Small mills may not find it practicable to install separate classifier and Wilfley treatment for the Wilfley middlings. In this case the middlings should not go directly back to the same table, but should be fed back into the mill classifier. The logic of this is that the presence of the large grains of concentrates in the Wilfley middlings is due mainly to imperfections of classifier work, and by sending them through the classifier again they may reach their proper destination. Of course included grains will come back to the same table again and will accumulate in the system until the tableman unconsciously works them off partly into the concentrates and partly into the tailings.

*Progress and Future.*—In an article on Progress in Mill Design Frank E. Shepard[2] covers briefly the present condition of the art and its tendencies. The following ideas have been selected from his article as being of particular interest from an authority like Mr. Shepard.

Hand sorting can be used more than at present, for the purpose of removing shipping ore and waste and increasing tonnage and efficiency of the mill and reducing slime losses.

Coarse crushing may be performed in the mine where it has the advantage of allowing waste to be picked out and not hoisted to the surface and also of making the crushed ore easier to handle than large lumps.

[1] *Min. and Sci. Press*, Vol. CIV (1912), p. 495.
[2] *Eng. and Min. Journ.*, Vol. XCIII (1912), p. 543; *Mexican Min. Journ.*, Vol. XV (1912); p. 30; *Met. and Chem. Eng.*, Vol. X (1912), p. 215. From Colorado Scientific Society.

For best results ore should be kept uniformly mixed in the bins. For example, coarse and fine ore should not be allowed to separate and cause variations in mill feed and consequent changes in adjustment of the machines. In extreme cases a system of ore bedding such as used by smelters may be advantageous.

Careful sampling both of mill feed and of the feed and products of individual machines is necessary in all testing of mill work to secure highest efficiency.

For fine crushing, rolls have the field down as fine as about 0.04 in. Stamps are useful only in certain work such as gold milling. The modern stamp shows improvements in cast-steel parts, narrow mortars, no inside amalgamation, heavy concrete foundations and frames of steel and concrete. Chile mills are much used for regrinding, but have the disadvantage of heavy renewals. Ball mills have the advantage in a mill where no coarse concentration is practised, that in one operation they reduce material from a breaker down to a size suitable for Wilfley table work. Ball mills having the perforated step plates are too complicated, but those having the scoop feed and the tire discharge obviate this trouble. Comparison of ball mill with Chile mill and stamp is shown in the table.

| | Capacity per 24 Hours, Tons. | Horse-power. | Weight of Crushing MovingParts, Pounds. | Total Weight, Pounds. | Price. |
|---|---|---|---|---|---|
| Chile mill, 6 ft. diameter | 40–50 | 25 | 20,000 | 50,000 | $3600 |
| Stamp mill, ten 850 lb | 40–50 | 20 | 8,500 | 35,000 | 2100 |
| Ball mill 4×6 ft. | 70–80 | 25 | 3,500 | 20,000 | 1600 |

The tube mill is especially adapted to production of slimes although some mills use it in concentration, obtaining a granular pulp by increasing the rate of feed to the tube mill.

Jigs cover the field between 2 1/2 in. down to 1 mm. The Richards pulsator jig is doing good work on sized products.

Good classification means increased extraction in all mill work. The Richards pulsator classifier is now supplied in launder form to meet the needs of some mills.

Dewatering has led to improved results in milling. It removes the slimes from coarser products and allows a more efficient separation of the latter and a separate treatment of the former. The final dewatering of slimes allows water to be recovered for use again in the mill.

## Examples of Milling Practice

*Concentration of Iron Ores.*[1]—Increasing attention is being paid to the beneficiation of low-grade iron ores.

The Trout Lake mill of the Oliver Iron Mining Company at Coleraine in the Mesabi district is running continuously every season. The total capacity of its five units is 35,000 tons in 24 hours. The practice of the mill as outlined[2] has been modified by the addition of twenty Overstrom tables in each unit to treat the fine material from the turbo log washers. For economy and efficiency a corrugated wood surface is used instead of riffles. Tests made in this mill on ore shipped from various parts of the district have shown that the method is suitable for practically all types of low-grade Mesabi ores.

At Moose Mountain in the Georgian Bay district finely disseminated magnetite is concentrated by the Gröndal wet magnetic system in an 800-ton mill modelled after the practice at Sydvaranger, Norway.

*Tin Dressing in Bolivia.*—Several modern plants are now in operation in Bolivia on tin ores.

The Llallagua mill, 40 miles from Oruro, started work in 1909.[3] Its capacity is 210 tons in 10 hours or 70 tons for each of the three units. Near the surface the cassiterite is associated with oxide of iron, but at depth occur also pyrite, chalcopyrite, bornite, argentiferous tetrahedrite, blende and wolfram. The ore is broken at the mine and delivered by aerial tramway to hopper (1) in each unit followed by feeder (2) to wash trommel (3) where sand and slime are carried away through a 4-mm. screen at the end to 2.5 mm. trommel (5). Over 2.5. mm. goes to trommels (17) and undersize to classifier (7). The cleaned ore from the wash trommel goes to trommel (4) which separates it into three classes 50 to 35 mm. and 35 to 20, and 20 to 4. The last goes to trommel (15) while the first two go to two bins (8) which feed two picking tables 4 meters in diameter. Here high-grade ore and waste are removed and the residues go separately to rolls (12) 1 meter in diameter and rolls (13) 0.7 meter in diameter. The rolls products are elevated (14) to trom- (15) having holes 20, 15 and 5 mm. Over 20 mm. goes to rolls (13), 20 to 15 mm. goes to jigs (16) and the remaining ore goes to trommels (17) and classifier (7). The trommels have 10-, 6.5-, 4.5-, 2.5-, and 1-mm. holes. The five oversizes and the sand from the classifier go to jigs (18) and (19) making concentrates and tailings and middlings which are elevated to a trommel (21) with 2.5-mm. holes. The oversize is

[1] N. V. Hansell, *A. I .M. E., Bulletin* No. 72, Dec., 1912, pp. 1497, 1565; *Met. and Chem. Eng.*, Vol. X (1912), p. 811; J. W. H. Hamilton, *Iron Age*, Vol. XC (1912), p. 1034; *Iron Tr. Rev.*, Vol. LI (1912), p. 1013. D. E. Woodbridge, *Eng. and Min. Journ.*, Vol. XCIII (1912), p. 222; *Iron Age*, Vol. LXXXIX (1912), p. 163.

[2] Richards "Ore Dressing," Vol. IV, p. 1815; Mineral Industry, Vol. XVIII, p. 953.

[3] *Min. Mag.*, Vol. VI (1912), p. 208.

recrushed in rolls (22) and sent back to the jigs while the undersize is ground in a pendulum mill (23) similar to a Huntington, with 0.8-mm. screen and is then classified (26) into coarse material to jigs (25) and slime. This slime joins that from (7) and goes to spitzkasten (26) and thence through mixing cone (27) to Humboldt tables (28) and a Bartsch round percussion table (29) for finest slime. The table middlings are re-treated on secondary Humboldt tables (31) and Bartsch table (32). The middlings from these are returned by pump (33). During one month the mill treated 3338 tons of ore averaging 7.15 per cent. tin. The concentrates contained 65.1 per cent. tin, and the recovery was 96.08 per cent. The complex ore from the deeper workings has been found to require roasting and magnetic separation in order to obtain a better quality of concentrate.

At the Savacon de Oruro mill[1] which deals entirely with the complex sulphide ore, the ore is first crushed dry in ball mills to 1 mm. and then roasted in hand-fired reverberatories with 4 per cent. salt. The roasted ore is first leached with water to recover copper and part of the silver and then with hyposulphite to recover the balance of the silver. The leached residue is classified and concentrated on jigs and tables. The ore contains tin, copper, silver, lead, gold, antimony, arsenic, sulphur, etc., and the operation saves more or less of the first five metals.

*Concentrating Furnace Slags.*—Many furnace slags contain prills and matte which yield good recoveries by wet crushing in a Hardinge mill and concentrating on tables.[2]

*Joplin Practice.*—The ore dressing methods, machines and mills for zinc ores in the Joplin district, Missouri, together with costs and results have been described and discussed very fully by J. L. Bruce.[3] He commends the jigging practice but feels that improvement may be made in sand and slime classification and table treatment and in the mill construction.

*Lake Superior Copper Mills.*—The rock houses for copper ore at Lake Superior vary somewhat in methods. The Quincy system[4] uses grizzlies previous to breakers; the Copper Range system[5] does not.

The new Ahmeek copper mill at Lake Superior[6] has four heads of Nordberg steeple compound steam stamps to treat amygdaloid copper ore.

[1] O. G. Adams, *Aust. Min. Stand.*, Feb. 8, 15 and 22, 1912; *Min. Mag.*, Vol. VI (1912), p. 301; *Met. and Chem. Eng.*, Vol. X (1912), p. 316.

[2] H. W. Hardinge, *Eng. and Min. Journ.*, Vol. XCIII (1912), p. 1262.

[3] *Eng. and Min. Journ.*, Vol. XCIII (1912), pp.. 405, 459, 501, 553.

[4] T. C. Desollar, *Lake Superior Min. Inst.*, Vol. XVI I (1912), p. 217; *Met. and Chem. Eng.*, Vol. X (1912), p. 678; *Min. and Eng. World*, Vol. XXXVII (1912), p. 529.

[5] H. T. Mercer, *Lake Superior Min. Inst.*, Vol. XVII (1912), p. 283; *Met. and Chem. Eng.*, Vol. X (1912), p. 680; *Min. and Eng. World*, Vol. XXXVII (1912), p. 807; *Eng. and Min. Journ.*, Vol. XCIV (1912), p. 349.

[6] W. R. Hodge, *Eng. and Min. Journ.*, Vol. XCIV (1912), p. 749; *Met. and Chem. Eng.*, Vol. X (1912), p. 795.

For the new regrinding plant for Calumet & Hecla tailings[1] it has been decided after extended tests to use Hardinge mills instead of Chile mills, as originally planned.[2]

*Treatment of Complex Ores.*—The Tam O'Shanter mill at Ashcroft, Colorado,[3] treats a complex lead-zinc-iron sulphide ore carrying some silver and copper. The gangue consists of hard quartz and wall rock. The ore is brought by aerial tram to (1)

1. Bin holding 200 tons. To (2).
2. Grizzly with 2-in. spaces. Oversize to (3); undersize to (4).
3. Blake breaker crushing 15 tons per hour. To (4).
4. Belt conveyor. To (5).
5. Mill storage bin holding 100 tons. By Challenge feeder to (6).
6. No. 1 rolls 14×27 in. To (7).
7. Bucket Elevator with 12-in. belt. To (8).
8. No. 1 trommel, 3×6 ft., 5-mm. holes. Oversize to (9); undersize to (10).
9. No. 2 rolls. Like (6). To (7).
10. No. 2 trommel. Like (8). 10 mesh. Oversize to (13); undersize to (11).
11. No. 3 trommel. Like (8). 20 mesh. Oversize to (13); undersize to (12).
12. Classifier with five spigots. Spigots to (16); overflow to waste.
13. Double Harz jig four compartments for coarse ore and four for fine ore. First hutch lead concentrates, second, third, and fourth, zinc middlings to (14); tailings to waste.
14. Tube mill 4×10-ft. grinding to 20 mesh. By elevator to (15).
15. Callow tank, 8-ft. Spigot to (12); overflow to lead concentrates bin.
16. Five tables. Lead concentrates to bin; zinc middlings by centrifugal pump to storage pile; tailings to waste.

The lead concentrates bins hold 100 tons each and have cocoa matting filter bottoms.

Electric motors are used throughout. The capacity is 3.5 tons per hour and the cost of milling is $0.50 per ton. The concentration ratio is 8 into 1 for lead and 10 into 1 for zinc. One superintendent, one crusher man and six mill men (in three shifts) operate the mill 24 hours.

Results are shown in the table:

| Products. | Tons 24 Hours. | Per Cent. Weight. | Assays. | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Ounces Silver. | Per Cent. Lead. | Per Cent. Zinc. | Per Cent. Iron. | Per Cent. Copper. | Per Cent. Silver. |
| Mill feed | 76.00 | 100.0 | 9.5 | 7.8 | 7.6 | 7.0 | 0.7 | 38.0 |
| Lead concentrates | 11.40 | 15.0 | 25.0 | 40.5 | 10.0 | 11.6 | 1.5 | 5.5 |
| Zinc middlings | 9.50 | 12.5 | 13.0 | 5.5 | 20.5 | 10.5 | 0.9 | 17.0 |
| Tailings | 55.10 | 72.5 | 2.0 | 0.5 | 2.6 | 5.0 | 0.1 | 52.0 |
| Jig feed | 40.28 | 53.0 | ..... | ..... | ..... | ..... | ..... | ..... |
| Table feed | 35.72 | 47.0 | ..... | ..... | ..... | ..... | ..... | ..... |

| | Silver. | Lead. | Zinc. | Iron. | Copper. |
|---|---|---|---|---|---|
| Per cent. in lead concentrates | 54 | 78 | 20 | 25 | 33 |
| Per cent. in zinc middlings | 23 | 8 | 34 | 18 | 16 |
| Per cent. in tailings | 15 | 5 | 25 | 51 | 10 |

The ore of the Yellow Pine Company at Good Springs, Nevada,[4] is

[1] MINERAL INDUSTRY, Vol. XX, p. 843.
[2] *Met. and Chem. Eng.*, Vol. X, (1912), p. 795.
[3] J. M. McClave, *Mines and Minerals*, Vol. XXXII (1912), p. 492.
[4] F. A. Hale, Jr., *Eng. and Min. Journ.*, Vol. XCIV (1912), p. 68; *Salt Lake Min. Rev.*, July 30, 1912, p. 33.

particularly difficult to concentrate consisting mainly of carbonates and sulphates of lead and zinc in limestone. The ore is screened over a 3/4-in. grizzly at the mine and the two sizes sent separately to (1).

1. Two bins. Total capacity 300 tons. Coarse ore to (2); fine ore elevated to (4).
2. Eighteen-inch conveyor belt inclined 30 degrees. Four men pick out waste limestone from this belt. Residue to (3).
3. Blake breaker, 8×12 in., crushing to 1 in. To (4).
4. Fine ore bin. By feeder to (5).
5. Gates rolls 16×30 in. crushing to 7 mm. To (6).
6. Ten-inch vertical elevator to (7).
7. Colorado Impact screen 3×3 ft., with 4-mm. holes. Oversize to (9); undersize to (8).
8. Colorado Impact screen, 3×3 ft., with 20-mesh holes. Oversize to (10); undersize to (12).
9. Two-compartment Harz jig. Lead concentrates to bin; tailings to (11).
10. Two-compartment Harz jig. Lead concentrates to bin; middlings to (11); tailings to zinc concentrates bin.
11. Rolls, 16×30 in. To (6).
12. Overstrom inverted classifier with six compartments. Six products to (13).
13. Six special Overstrom tables with grooved linoleum tops. Lead concentrates to bin; middlings (from two coarsest sizes only) to (11); tailings to zinc bin; slimes to (14).
14. Cone settling tanks. Spigot to (15); overflow clear water for mill.
15. Slime ponds where slime dries in sun for shipment.

The only waste product in this mill is the limestone picked out on (2). The mill treats 75 tons in 24 hours. The feed averages 28 per cent. zinc, 17 per cent. lead and 10 oz. silver per ton. The lead concentrates average 62 per cent. lead and 45 oz. silver and the zinc product contains 33 to 35 per cent. zinc.

The new Butte Central mill at Butte, Montana, is designed to treat an ore containing auriferous sulphides of lead, copper, zinc and iron in a siliceous gangue.[1]

A very interesting comparison of graded crushing and concentration and single-stage crushing and concentration is offered by the Lucky Tiger mills at El Tigre, Sonora, Mexico.[2] The ore is auriferous and complex containing sulphides of lead, copper, zinc, iron, silver, etc., in a siliceous and lime gangue. For further details of these mills and their operation the reader is referred to the original article which is very complete.

The Butte and Superior mill at Butte, Montana, is a combination wet concentration and flotation plant. During the past year it has passed through a period of experiment, and the original installation has been changed considerably. Butte and Superior ore consists of zinc blende in coarse and fine dissemination with about 1 per cent. each of pyrite and galena in a gangue composed for the most part of very hard quartz with a little rhodonite and some decomposed granite.

The mill is divided into two sections, one of which is as follows:

The ore from the mill bin is sent to an elevator and screened dry over six Colorado impact screens of which the opening is, at present, about 2.2 mm. The oversize from these screens drops to two 42×16-in. Tray-

[1] *Met. and Chem. Eng.*, Vol. X (1912), p. 426; *Min. and Eng. World*, Vol. XXXVI (1912), p. 1091; *Min. Journ.*, Vol. XCVII (1912), p. 579.

[2] D. L. H. Forbes, *A. I. M. E., Bulletin*, No. 68, Aug., 1912, p. 769; *Mexican Min. Journ.*, Vol. XV, (1912), p. 26; *Eng. and Min. Journ.*, Vol. XCIV (1912) pp. 498, 690.

lor rolls and back to the elevator, while the undersize with water is delivered to six double-decked Garfield roughing tables. These tables make a rough zinc-lead concentrate, a rough zinc concentrate and middlings which pass to the Chile mill elevator, and thence to four five-compartment Richards-Janney classifiers. The spigot products of these classifiers are treated on double-decked roughing tables which also make rough zinc-lead concentrates and rough zinc concentrates. The tailings from the roughing tables treating first and second spigot material pass to Chile mills and are then returned to the Chile mill elevator. The tailings from the third and fourth spigot tables pass to the tube mill elevator, while the tailings from the fifth spigot together with the classifier overflow, flows to thickening tanks.

The tube mill elevator delivers to three de-slimers, one of which is a Dorr and two are Akins. The sand from these goes to three 4 1/2×20-ft. tube mills, thence to three four-compartment Richards-Janney classifiers. The spigot products of these are treated on four roughing tables making the same products as the upper tables, the tailings from No. 1 and No. 2 spigots being returned to the de-slimers, while the tailings from spigots 3 and 4, with the classifier overflow, go to the thickening tanks.

Beside the roll grinding circuit, there are thus two closed combination grinding and concentrating circuits in the mill, from which the ore does not escape until it has attained the necessary reduction.

The rough zinc-lead concentrates from all the roughing tables are delivered to an elevator, thence to a four compartment classifier, each spigot discharge of which is treated on a Wilfley table. These make a clean lead concentrate, a mixed lead and zinc concentrate which is returned to the lead elevator, and a clean zinc concentrate as well as a small amount of tailings which is sent to the zinc elevator. The rough zinc concentrates of the Garfield tables go to the zinc elevator, and from there pass over two sets of impact screens. The oversize of each of these sets of impact screens is treated in three-compartment jigs, while the undersize flows to two four-compartment classifiers. The spigot discharges from these classifiers are treated on six Wilfley tables, making a mixed zinc-lead concentrate which goes to the lead elevator, a clean zinc concentrate and tailings which pass to the tube mill elevator. The jigs make clean zinc concentrates, the tailings going also to the tube mill elevator.

For thickening the pulp there are six 28-ft. settling tanks and sixty-four 8-ft. conical tanks. These tanks serve both sections of the mill. The spigot discharge from them is delivered to the Hyde flotation plant.

The capacity of the mill is 1000 tons per 24 hours. The feed averages about 20 per cent. zinc, and recovery averages about 90 per cent.

by caterpillar feeders and belt conveyors to (1).

1. Grizzly with 1-in. spaces. Oversize to (2); undersize to (7).
2. No. 8 McCully gyratory breaker crushing to 2 1/4-in. ring. To (3).
3. Grizzly with 1-in. spaces. Oversize to (4); undersize to (7).
4. Vertical bucket elevator to (5).
5. One set 20×72-in. Garfield rolls, set 3/4 in. apart. To (6).
6. Screen grizzly with 1-in. holes. Oversize to (4); undersize to (7).
7. Belt conveyor to (8).

The coarse crushing department has a capacity of 450 tons per hour. From unit is described.

8. Two circular steel tanks for fine ore, holding 1000 tons each. By four cat
9. Two vertical bucket elevators. To (10).
10. Two 6-mesh impact screens. Oversize to (11); undersize to (15).
11. Two sets Garfield rolls, 16×42. To (12).
12. Four 7-mesh impact screens. Oversize to (13); undersize to (16).
13. One 2-mesh screen. Oversize to (9); undersize to (14).
14. Four bull jigs. Concentrates; tailings to (9).
15. Eight Garfield roughing tables. Concentrates to (17); tailings to (18).
16. Six Garfield roughing tables. Concentrates to (17); tailings to (18).
17. Six Wilfley tables. Concentrates; tailings to (18).
18. Bucket elevator. To (19).
19. Four 4-spigot Richards-Janney classifiers. First and second spigots to (22); fourth spigot to (23); overflow to (26).
20. Three Chile mills with 12-mesh screens. To (21).
21. Two 3-spigots Richards-Janney Classifiers. Spigots to (16); overflow to
22. Two 5-spigot Richards-Janney classifiers. First four spigots to (15); fift flow to (26).
23. Two 5-spigots Richards-Janney classifiers. Spigots to (25); overflow to
24. Four Isbell vanners. Concentrates; tailings to (28).
25. Twenty Isbell vanners. Concentrates; tailings to (28).
26. Forty Callow cones for dewatering. Spigots to (27); overflow to (29).
27. Seventy-two Isbell slime vanners. Concentrates; tailings to (29).
28. Two Callow cones for dewatering. Spigots to waste; overflow to (29).
29. Settling tanks with thirty rectangular sections each about 20×18×8 f Settlings to waste; clear water pumped back to mill.

The concentration ratio is 14 tons into one, and the rec is about 60 per cent. The ore is automatically samp delivery to bins (8). The mill is of steel frame and concr Electric power is used from a central steam generating pla

*Milling in Upper Silesia.*—The new mill for treating zinc predominating from the Bleischarley mine at Bet Silesia has been put in operation after a four weeks' trial r

divisions for rich middlings and two divisions for poor middlings. The slime department contains six divisions for original slimes, two divisions for poor slimes, two divisions for rich slimes, and two divisions for mixed slimes.

The operation of the mill makes use of breakers and rolls for original crushing, hand picking, wash trommels, trommels for sizing, jigs both coarse and fine, rolls and roller mills for recrushing, classifiers and spitzkasten, riffle tables and round tables. There are also unwatering trommels and large settling tanks. For full details the reader is referred to the original article and also to an article by O. Putz[1] which gives a very full account of the entire ore-dressing operations in Upper Silesia.

*Australia.*—The new Junction North mill at Broken Hill crushes the ore by gyratory breaker, jaw breaker and rolls to pass through 3-mm. Callow screens, and is then sized on 0.5-mm. screen. Over 0.5 mm. is jigged in two three-hutch two-compartment May jigs, making lead concentrates and tailings to tube mills. Under 0.5 mm. is separated on roughing tables yielding lead concentrates and tailings. The tube mills are 10×5-ft. Krupp mills and are followed by 5-ft. grinding pans grinding to 0.5 mm. The ground product and table tailings are unwatered and treated in two Mineral Separation flotation units making worthless gangue and mixed sulphides of lead, silver and zinc, which are unwatered, classified and finally separated into lead and zinc concentrates on Wilfley tables, sand vanners and slime vanners.

*Cananea Practice.*—Valuable data for the millman are given by A. Tellam[2] in describing the results at the mill of the Cananea Consolidated Copper Company. For every machine in the mill figures are given on tonnage, water, sizing tests, per cent. copper, and extractions. The data are too voluminous to be reproduced here.

*Separating Rock from Stiff Clays.*—The disintegration of a clayey ore before crushing may be effected by log washers, wash trommels, puddling machines, trough washers or hydraulic jets. An example of the use of the last named on a gold ore in Dutch East Indies is given by F. A. Killik.[3]

## Treatment of Coal

*General Theory and Testing.*—The washing of coal is on the increase and moreover there is a tendency to look into the matter from the scientific point of view and make thorough tests rather than to depend entirely on manufacturers. There is still much room for improvement

[1] *Metall und Erz*, Vol. X (1912), p. 41; *Deutsche Bergwerks Zeitung*, Oct. 1, 1912, p. 1.
[2] *Min. Mag.*, Vol. VI (1912), p. 272.
[3] *Inst. of Min. and Met.*, Vol. XXI (1912), p. 230; *Mines and Methods*, Vol. III (1912), p. 419; *Eng. and Min. Journ.*, Vol. XCIII (1912), pp. 304, 738; *Min. and Eng. World*, Vol. XXXVI (1912), p. 61; *Min. Sci.*, Vol. LXV (1912) p. 47.

in increasing efficiencies, reducing wastes and effecting economies both in installing and in operating.

The use of jigs with more than one compartment may be a disadvantage[1] in that the rush of water on the later compartments may cause refuse to go over with the coal. Four single compartment jigs in coal work are usually better than one four-compartment jig. Losses occur in fine coal sludge where water is used over and over, this sludge being held in suspension in the water, and escaping with the water discharged with the refuse. The remedy for this is to increase the settling capacity for sludge. All parts in the washery should be standardized as far as possible.

In testing the work of a coal washery it is not enough to make analyses for ash, but a float and sink (heavy solution) apparatus[2] is also essential to determine whether the products are up to standard.

The computing of the efficiency of a plant should cover both the percentage of good coal going into the refuse and the percentage of refuse left in the good coal. In using heavy solution for these tests the first step is to determine the permissible bath, that is the specific gravity of solution that will give the most profitable separation from a commercial viewpoint. There is some difference of opinion as to the proper method of computing efficiencies which shall take into consideration the imperfect work in both the washed coal and the refuse. Delamater's[3] ideas as to the proper method making use of results of heavy solution tests are expressed by the following formulas.

### Coal Washing Formulæ

$L$ = Loss of good coal in the refuse.
$W$ = Washed coal efficiency.
$R$ = Refuse efficiency.
$T$ = Total efficiency.
$D$ = per cent. reduction of the impurity.
$M$ = Percentage of the impurity actually removed by washing.
$a$ = per cent. of raw coal (always 100 per cent.).
$b$ = per cent. of raw coal float.
$c$ = per cent. of raw coal sink.
$d$ = per cent. of ash (or sulphur) in the raw coal.
$e$ = per cent. of washed coal.
$f$ = per cent. of washed coal float.

[1] G. R. Delamater, *Coal Age*, Vol. II (1912), p. 865.
[2] G. R. Delamater, *Coal Age*, Vol. II, 1912, p. 82; Mineral Industry, Vol. XVII, p. 963, Vol. XIX, p. 779.
[3] G. R. Delamater, *Eighth International Congress of Applied Chemistry*, Vol. X, (1912) p. 129; *Mines and Minerals*, Vol. XXXII (1912), pp. 461, 536, 660; *Coal Age*, Vol. I, p. 1115.

$g$ = per cent. of washed coal sink.
$h$ = per cent. of ash (or sulphur) in the washed coal.
$i$ = per cent. of refuse.
$j$ = per cent. of refuse float.
$k$ = per cent. of refuse sink.
$l$ = per cent. of ash (or sulphur) in the refuse.

Formula No. 1. For Determining the value of ($L$).

$$L=\frac{ji}{b}$$

Formula No. 2. For determining the value of ($W$).

$$W=100-g.$$

Formula No. 3. For determining the value of ($R$).

$$R=100-j.$$

Formula No. 4. For determining the value of ($T$).

$$T=\frac{W+R}{2}$$

Formula No. 5. For determining the value of ($D$).

$$D=\frac{d-h}{d}$$

Formula No. 6. For determining the value of ($M$).

$$M=\frac{d-(eh)}{d}$$

Formula No. 7. For determining the value of ($i$).

$$i=\frac{\frac{f}{g}c-b}{\frac{f}{g}k-j}=\frac{fc-gb}{fk-gj}$$

Or, if value of ($e$) is known, then, $i=100-e$.

Formula No. 8. For determining the value of ($e$).

$$e=\frac{\frac{k}{j}b-c}{\frac{k}{j}f-g}=\frac{kb-jc}{kf-jg}$$

Or, if the value of ($i$) is known, then $e=100-i$.

Formula No. 9. For determining the value of ($i$) from the analysis data.

$$i=\frac{d-h}{l-h}$$

Formula No. 10. For determining the value of ($l$).

$$l=\frac{d-he}{i}$$

Formula No. 11. For determining the value of $(h)$.

$$h=\frac{d-li}{e}$$

If the float and sink tests are all correct, the following formulæ should check.

Formula No. 12.

$$ji+fe=b$$
and
$$ki+ge=c.$$

Special Note: It must be remembered that the same specific gravity of bath (permissible) must be used throughout all calculations with these formulæ. Likewise, where analyses are used, they must all be reduced to a dry basis, otherwise the variation in moisture would greatly affect the results.

An elaborate government investigation of the coals of Canada is under way at McGill University, Montreal, and the results are given in six volumes.[1]

*Apparatus.*—In installing coal screens room should be allowed for changes.[2] For highest efficiency the screens should have even feed. Where the coal breaks into flat fragments slotted screens should be used with the slots widening slightly toward the lower end and the screens should be arranged in steps with a little drop between.

A study of the development of German coal washing practice during the last ten years shows that much progress has been made. For lump screens the oscillating cross-bar type such as the Distl Suski, Seltner, and Groppel screens have come into use. Dust is retained by proper housings and removed by suction fans.[3] For full details of the apparatus and methods the reader is referred to the original article.

*Anthracite Practice.*—The new anthracite breaker at Harleigh[4] just outside of Hazleton, Pennsylvania, has several new features. The preliminary treatment in the preparation house saves a lot of work in the main breaker, and also reduces the height of the main breaker.

This breaker can prepare 1400 to 1500 tons daily.

The new Buck Mountain anthracite breaker[5] near Mahanoy City, Pennsylvania, is of concrete and steel fireproof construction with large window area for light and air.

[1] Canada Department of Mines, Mines Branch. An Investigation of the Coals of Canada, by J. B. Porter and R. J. Durley. See also *Min. Sci.*, Vol. LXV (1912), pp. 393, 412.
[2] B. Shubart, *Coal Age*, Vol. II (1912), p. 709.
[3] Eschenbruch, *Zeitschrift für das Berg. Hutten und Salinenwesen*, Vol. LX (1912), p. 1.
[4] F. B. Davenport, *Coal Age*, Vol. II (1912), p. 250.
[5] E. L. Cole, *Coal Age*, Vol. I (1912), pp. 1032, 1067; *Mines and Minerals*, Vol. XXXII (1912), p. 637.

The capacity of the plant is 1800 tons of coal daily by a force of only 36 employees.

The Alstaden Company near Oberhausen, Germany, has a new washery to treat anthracite coal.[1] The capacity is 900 tons in 16 hours. The problem is to break the coal into small pieces, remove the dust, wash the residue, and mix the washed coal with the unwashed dust to go to the briquetting plant.

The cars are dumped by revolving tipple to (1).

1. Shaking screen with 3.15-in. round holes. Oversize to (2); undersize to (6).
2. Picking belt where slate is sorted out and sent to tram cars and raised by platform elevator to dump level. Residue to (3) or to storage pile by tram cars whence it is returned when needed in winter by cars and platform elevator to (3).
3. Rolls crushing to nut size. By elevator to (4).
4. Shaking screen with 1.97-in. holes. Oversize to (5); undersize to (6).
5. Jaw breaker crushing to 1.97 in. To (6).
6. Bin. By bucket elevator to (7).
7. Two shaking screens with 1.57, 0.59, and 0.12-in. holes. Three oversizes to (8); undersize by scraper conveyor to one compartment of (12).
8. Jig with six compartments. First compartment treats coarsest size; next two compartments treat medium size and last three compartments treat finest size. Coal from first three compartments to (9); from last three to (12); slate to (13).
9. Two screens with 1.97-in., 1.18-in., 0.59-in. and 0.315-in. holes. Oversizes of 1.97 in. and 1.18 in. to (10); two other oversizes to two compartments of (12); undersize to (11).
10. Two picking belts where light bituminuous shale is picked out. Residue to two compartments of (12).
11. Sump and drainage elevator with perforated buckets. To two compartments of (12); water to (14).
12. Cleaned coal bin with compartments for various sizes. Spiral chutes to prevent breakage of incoming coal. Filter bottoms to allow drainage. Screens and water sprays at discharge chutes to remove fines which go to (11).
13. Sump and elevator for waste. To cars for dump. Water to (11).
14. Spitzkasten. Settlings to (15); overflow clear water pumped back and reused.
15. Three draining sludge sumps. Sludge used as full in boiler house; overflow to (11).

*Bituminous Practice.*—To wash nut and slack coals from various mines before coking, the Durham Coal and Iron Company has installed[2] a new washer at Soddy, Tennessee. These coals present different problems in the way of slate, bone and fire-clay contents. A Stewart jig with one compartment is used for nut coal and two Roberts and Schaefer jigs, each with three compartments for slack. Each jig has a capacity of 25 tons per hour. The scheme of treatment is shown in the accompanying diagram. (Fig. 10.)

The percentage of washed coal recovered is approximately 75 per cent. Analyses are as follows:

| | Per cent. Ash. |
|---|---|
| Unwashed 3/4-inch slack coal | 21.30 |
| Washed slack coal | 10.95 |
| Refuse, final (includes nut refuse) | 58.15 |
| Unwashed nut coal | 20.33 |
| Washed nut coal | 9.85 |
| Refuse nut coal | 58.28 |

The tendency toward fire-proof construction is shown by the new washery for bituminous coal at Panama, Illinois.[3]

A double New Century jig has been installed at Lahausage, Alabama,

[1] *Mines and Minerals*, Vol. XXXIII (1912), p. 193.
[2] F. E. Mueller, *Coal Age*, Vol. II (1912), p. 528.
[3] J. A. Garcia, *Coal Age*, Vol. I (1912), p. 964; *Eng. Record*, Oct. 26, 1912, p. 465.

to wash bituminous coal crushed in a Williams crushing mill and ranging from 1.5 in. to 0 in size. The washed coal is drained in an elevator with perforated buckets. The jig treats 350 tons per day and the ash is reduced from 14.10 per cent. in the raw coal to 9.43 per cent. in the washed coal and the sulphur from 1.20 per cent. to 0.97 per cent.[1]

With the increasing demand and value of coal, attention has been turned to the recovery of sludge for firing the boilers at the coal washery.[2]

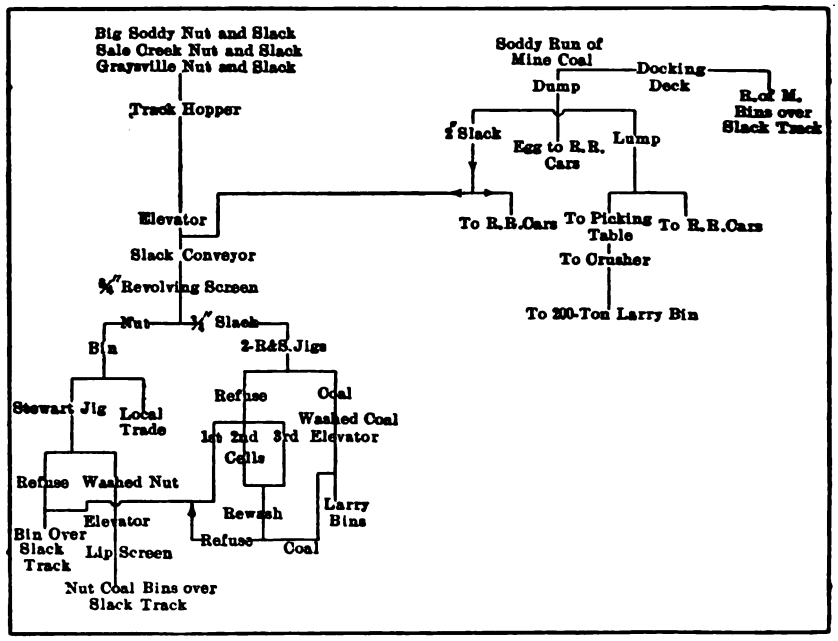



FIG. 10.—Tree of Soddy washer.

At the Heinitz washery in the Saar district[3] the fine coal below 1 mm. in size goes to two spitzkasten each having six compartments. The products from the first and second compartments are jigged on a two-sieve feldspar jig making coal and waste. The overflow of the spitzkasten is clear water. The products from the remaining four spigots are screened in a 0.4 and 0.6-mm. trommel. The oversize of both trommels is clean coal. The undersizes are sent to three slime washing tanks making clean coal and waste. The original fine coal contains about 33 per cent. ash, and the washed coal contains between 8 and 12.5 per cent. ash. The waste from the jigs carries 69.6 per cent. ash, and that from the slime washing tanks 48.4 per cent. ash.

[1] D. A. Willey, *Mines and Minerals*, Vol. XXXII (1912), p. 391.
[2] Th. Moehrle, *Oesterreichische Zeitschrift*, Vol. LX (1912), pp. 340, 358; *Kohle und Erz*, 1912, p. 49.
[3] *Zeitschrift für das Berg.-Hütten.- und Salinenwesen*, Vol. LX (1912), p. 130.

DATA OF THE WORLD'S PRINCIPAL MINES.
By S. F. Shaw.

| ıe of Mine. | Loc. | Year. | Tonnage Produced. | Profits. | Dividends. | Cost per Ton. | Ore Reserves Tons. |
|---|---|---|---|---|---|---|---|
| ı..... | *j* | 1911 | 45,514 | $206,590 | ..... | $16.51 | 340,200 |
| old ..... | *z''* | 10–11 | 68,746 | £2,157 | £20,000 | 9.44 | 213,997 |
| ..... | *z'* | 1911 | 598,549 | 870,272 | ..... | ..... | ..... |
| exican..... | *a* | 1911 | 227,081 | 157,881 | 126,000 | 2.06 | 980,025 |
| eadwell..... | *a* | 10–11 | 770,084 | 710,311 | 400,000 | 1.55 | 6,637,370 |
| nited..... | *a* | 1911 | 449,071 | 126,415 | 81,090 | 1.82 | 2,835,184 |
| ..... | *z'* | 1911 | 288,610 | 11,353 | *Nil.* | 2.20 | ..... |
| ated Zinc..... | *c* | 10–11 | 319,256 | £98,301 | £75,000 | ..... | ..... |
| ..... | *o* | 1911 | 73,793 | 242,339 | 240,000 | 5.77 | 587,856 |
| ..... | *z'* | 1911 | 4319,995 | ..... | 8,608,750 | 6.42 | ..... |
| in..... | *y* | 10–11 | 102,944 | ..... | ..... | 0.93 | ..... |
| Copper..... | *z'* | 10–11 | 744,746 | £189,217 | £214,518 | ..... | ..... |
| Goldfields..... | *z''* | 10–11 | 111,209 | £144,565 | £152,951 | 12.38 | 453,750 |
| d Gold Mg..... | *c* | 1910 | 128,181 | 141,181 | ..... | ..... | ..... |
| Mines of W. Aust. | *c* | 10–11 | 105,238 | £5,846 | ..... | ..... | ..... |
| . Blocks..... | *c* | 10–11 | 18,158 | £16,325 | ..... | 7.04 | 345,378 |
| est..... | *c* | 1911 | 131,359 | £28,959 | ..... | 4.77 | ..... |
| ..... | *c* | 1911 | 696,785 | 530,215 | 500,000 | 2.08 | ..... |
| ..... | *c* | 1911 | 273,212 | £53,137 | ..... | 5.67 | 896,087 |
| ..... | *z''* | 1911 | 67,565 | £2,052 | ..... | 6.37 | 397,759 |
| New Haven ..... | *z'* | 1911 | 285,426 | ..... | 228,689 | ..... | ..... |
| er ..... | *r* | 1911 | 44,038 | £26,744 | £37,498 | 7.02 | 70,979 |
| ıd Montana..... | *z'* | 1909 | 1,374,504 | ..... | ..... | ..... | ..... |
| ..... | *w* | 1911 | 241,204 | £110,568 | ..... | 2.23 | 1,925,346 |
| Extended..... | *c* | ½–11 | 27,580 | £10,002 | £12,500 | 8.84 | 40,000 |
| roken Hill..... | *c* | ½–11 | 63,370 | £15,142 | £26,400 | 6.43 | ..... |
| | | ½–11 | 81,777 | £61,910 | £45,000 | ..... | ..... |
| ol. Cop. Co ..... | *f* | 1911 | 384,588 | 133,929 | 147,931 | 4. | 3,300,009 |
| ill Bl. 10..... | *c* | ½–11 | 48,754 | ..... | £10,000 | ..... | ..... |
| ill Bl. 10..... | *c* | ½–11 | 33,831 | — £16,523 | ..... | ..... | ..... |
| ill Bl. 14..... | *c* | ½–11 | 10,753 | ..... | 11,500 | ..... | 220,000 |
| ill Bl. 14..... | *c* | ½–11 | 11,064 | ..... | ..... | 5.36 | ..... |
| ill North..... | *c* | ½–11 | 128,270 | £66,808 | £52,500 | 8.79 | 1,500,000 |
| ill Prop..... | *c* | 10–11 | 52,441 | £167,814 | £48,000 | ..... | ..... |
| ill South..... | *c* | ½–11 | 175,044 | £72,083 | £60,000 | 4.97 | ..... |
| | | | 181,790 | £144,423 | £90,000 | 4.85 | 3,000,000 |
| ..... | *s* | 10–11 | 41,484 | ..... | 370,000 | 10.09 | ..... |
| ill and Sullivan... | *z'* | 10–11 | 483,290 | 870,986 | 1,062,750 | 5.53 | ..... |
| ines..... | ..... | 1911 | 36,929 | £15,126 | ..... | 20.32 | ..... |
| l Boston..... | *z'* | 1910 | 372,965 | 751,712 | 399,680 | 6.98 | ..... |
| alvador..... | ..... | 1909 | 21,664 | £68,129 | £103,125 | 18.37 | 100,000 |
| and Ariz..... | *z'* | 1911 | 244,772 | 2,572,241 | 2,150,000 | 8.75 | ..... |
| and Hecla..... | *z'* | 10–11 | 2,795,514 | ..... | 2,400,000 | 1.92 | ..... |
| d..... | *z'* | 10–11 | 79,186 | £267,689 | £220,000 | 9.39 | 38,415 |
| Cons ..... | *o* | 1911 | 741,873 | ..... | ..... | 5.28 | ..... |
| per..... | *w* | 10–11 | 82,925 | £60,862 | £43,125 | ..... | 180,200 |
| a and Tincroft.... | *i* | ½–11 | 38,253 | — £1,936 | ..... | 5.46 | ..... |
| a and Tincroft.... | *i* | ½–11 | 41,670 | £5,297 | ..... | 5.43 | ..... |
| Copper ..... | ..... | 1909 | 30,100 | ..... | ..... | ..... | ..... |
| al Eureka..... | *z'* | 1911 | 108,275 | ..... | 300,000 | ..... | ..... |
| al..... | *z'* | 1910 | 106,095 | — 20,742 | ..... | ..... | ..... |
| ..... | *c* | 1910 | 46,584 | 23,000 | ..... | ..... | ..... |
| a..... | *z'* | 1911 | 347,885 | 60,371 | 500,000 | ..... | ..... |
| a Reef..... | *m* | 10–11 | 205,169 | £133,808 | £112,688 | 7.92 | 365,296 |
| ..... | *c* | 10–11 | 60,943 | £21,000 | ..... | ..... | ..... |
| a Deep..... | *w* | 1911 | 192,341 | ..... | ..... | 5.88 | 740,157 |
| p..... | *w* | 1911 | 349,913 | £90,935 | ..... | ..... | 2,078,805 |
| Suburban..... | *w* | 1911 | 316,679 | £162,523 | £153,000 | 4.76 | 789,084 |
| ..... | *s* | 10–11 | 52,489 | ..... | $1,440,000 | ..... | .....10 |
| ldfields of New .. | *r* | 1910 | 21,363 | ..... | £24,273 | 4.48 | 25,919 |
| l. | | | | | | | |
| n Reef..... | *w* | 10–11 | 252,485 | £87,974 | £80,881 | 5.22 | 516,844 |
| . and Smelt..... | *f* | 10–11 | 388,785 | 202,278 | ..... | ..... | ..... |
| cur..... | ..... | 10–11 | 239,190 | 496 | ..... | 2.32 | ..... |
| lueen..... | *z'* | 1911 | 619,182 | 4,155,011 | 5,200,000 | ..... | ..... |
| United Cop..... | *d* | 10–11 | 47,481 | £3,646 | ..... | ..... | ..... |
| ..... | *o* | 1910 | 107,500 | ..... | ..... | 4.74 | 284,310 |
| ines, Ltd..... | *w* | 1911 | 1,618,500 | £1,271,106 | £1,034,110 | 4.70 | 10,124,072 |
| eef..... | *w* | 1909 | 172,387 | £118,822 | ..... | ..... | ..... |
| eserve..... | *s* | 1910 | 2,749 | 1,368,124 | 1,050,000 | ..... | ..... |
| ge..... | *z'* | 1911 | 59,461 | ..... | $180,000 | ..... | ..... |
| st..... | *z'* | 1911 | 88,141 | 278,259 | 162,000 | ..... | ..... |
| ..... | *z'* | 1910 | 44,961 | £4,142 | £4,000 | 9.90 | ..... |

DATA OF THE WORLD'S PRINCIPAL MINES.—*Continued.*
By S. F. Shaw.

| Name of Mine. | Loc. | Year. | Tonnage Produced. | Profits. | Dividends. | Cost per Ton. | Ore Reserves Tons. |
|---|---|---|---|---|---|---|---|
| Detroit Copper | z′ | 1911 | 517,087 | $930,496 | $800,000 | $ | |
| Dolcoath | i | ½–11 | 40,315 | £36,370 | £34,000 | 7.67 | |
| | | ½–11 | 46,343 | £31,243 | £34,450 | 7.21 | |
| Dolores | o | 1910 | | | 270,000 | 12.60 | 64,739 |
| Dops Estrells | o | 1911 | 475,548 | 5,882,774 | 750,000 | 5.75 | 1,870,637 |
| Ducktown Sul. and Iron | z′ | 1911 | 145,688 | £25,958 | £25,954 | | |
| Durban-Roodepoort | w | 1911 | 165,662 | £3,803 | £50,000 | 5.87 | 661,791 |
| Durban-Roodepoort Deep | z | 1911 | 262,540 | £60,834 | £22,000 | 5.91 | 1,288,071 |
| East Butte | z′ | 11–12 | 95,910 | 256,643 | | 18.02 | |
| East Gwanda | t | 1909 | 91,400 | — £34,884 | | 6.46 | |
| East Rand Prop | w | 1911 | 2,194,552 | £858,801 | | 4.26 | 6,716,605 |
| Eldorado Banket | t | 10–11 | 82,802 | £92,742 | £90,000 | 6.61 | 179,341 |
| El Oro | o | 10–11 | 360,294 | | £172,125 | 3.90 | 484,139 |
| El Rayo | o | 1910 | | | 62,400 | 6.23 | 53,100 |
| Esperanza | o | 1911 | 250,022 | £133,868 | £136,500 | 4.43 | 200,443 |
| Famatina | b | 1911 | 188,570 | | | | |
| Federal | z′ | 10–11 | 759,108 | 1,241,115 | 839,027 | 5.88 | 863,340 |
| Ferreira | w | 1911 | 310,300 | £175,322 | £190,000 | | 324,603 |
| Ferreira Deep | z | 10–11 | 373,196 | £327,732 | £409,500 | 5.94 | 1,837,806 |
| Florence Goldfields | z′ | 1911 | 48,874 | — 42,008 | | | |
| Franklin Furnace | z′ | 1910 | 375,677 | | | | |
| Frontino and Bolivia | d | ½–11 | 17,147 | — £4,518 | | 9.19 | £24,166 |
| Gaika Gold | t | 10–11 | 29,550 | 11,777 | £13,024 | $6.52 | 30,000 |
| Geduld Prop | z | 1911 | 138,700 | — £4,958 | | 6.60 | 607,300 |
| Geldenhuis | z | 1911 | 801,860 | £209,456 | £175,725 | 5.47 | 2,262,840 |
| Giant | t | 10–11 | 123,789 | £97,860 | £49,360 | 4.10 | 308,146 |
| Ginsburg | z | 1911 | 138,459 | £56,901 | £52,500 | 5.07 | 367,646 |
| Globe and Phoenix | t | 1911 | 71,802 | £321,293 | £320,000 | 11.05 | 173,613 |
| Glynn's Lydenburg | w | 10–11 | 33,870 | £44,022 | £42,500 | 6.13 | 73,280 |
| Golden Horseshoe | c | 1911 | 269,667 | £22,715 | | 6.84 | 804,200 |
| Goldfield Cons | z′ | 1911 | 330,549 | 526,846 | 7,118,296 | 8.52 | 600,000 |
| Glencair | z | 1911 | 227,753 | £27,485 | £27,500 | 3.28 | 925,000 |
| Granby | f | 1910 | 1,175,548 | 564,946 | 270,000 | 3.08 | 6,250,000 |
| Great Boulder Perseverance | c | 1911 | 243,109 | £48,458 | | 4.84 | 807,864 |
| Great Boulder Prop | c | 1911 | 187,510 | £262,974 | £262,500 | 7.90 | 698,562 |
| Great Cobar | c | 10–11 | 475,988 | | | | 3,088,000 |
| Great Fingal | c | 1911 | 101,949 | £15,816 | £12,500 | | 84,738 |
| Great Fitzroy | c | 10–11 | 69,791 | — £9,836 | | 10.26 | 590,522 |
| Greene-Cananea | o | 1911 | 936,963 | 1,026,952 | | 5.05 | |
| Grenville | i | 1911 | 17,059 | £6,956 | | 6.65 | |
| Guanajuato Con | o | 1909 | 86,580 | | | 4.16 | |
| Guanajuato Red. Mines | o | 1910 | 228,344 | 376,837 | | 2.44 | 48,690 |
| Gwalia Cons | c | 10–11 | | — £10,712 | | | |
| Hainault | c | 10–11 | 62,322 | £4,607 | £3,750 | 6.21 | 100,000 |
| Hecla | z′ | 1911 | 136,479 | 287,103 | 240,000 | 5.23 | |
| Hedley Gold Mining | f | 1911 | 57,815 | 318,152 | 300,000 | | |
| Hercules | z′ | 10–11 | 25,765 | | 418,542 | | |
| Homestake | z′ | 10–11 | 1,468,263 | | 1,310,400 | 2.69 | |
| Homestake | z′ | ½–11 | 888,057 | | 764,400 | 2.53 | |
| Hornsilver | z′ | 1911 | | — 9,397 | | | |
| Hutti Gold Mine | m | 1910 | 38,706 | £9,236 | £3,480 | 6.44 | 40,000 |
| Independence (Stratton's) | z′ | 10–11 | 109,800 | £21,000 | £12,500 | | |
| Iron Blossom | z′ | 1910 | 35,933 | 299,242 | 280,000 | | |
| Iron Silver Mg. Co | z′ | 1911 | 42,673 | 187,600 | $100,000 | | |
| Isle Royal | z′ | 1911 | 457,440 | 156,708 | | 1.67 | |
| Ivanhoe | c | 1911 | 238,965 | £218,221 | £220,000 | 5.38 | 1,088,421 |
| Jubilee | w | 1910 | 55,011 | £2,428 | | | |
| Jumbo Gold | t | 10–11 | 40,490 | | | 8.48 | 30,803 |
| Jumpers | w | 10–11 | 120,802 | £43,865 | £40,000 | 7.25 | 122,314 |
| Jupiter | w | 1911 | 314,650 | £26,938 | | 5.12 | 1,089,000 |
| Kalgurli | c | 10–11 | 127,010 | £116,326 | £136,500 | 7.01 | |
| Kerr Lake | s | 10–11 | 1,810 | $937,379 | 1,200,000 | 162.46 | |
| Knight's Central | w | 1911 | 315,171 | | | | 644,300 |
| Knight's Deep | w | 10–11 | 695,670 | £252,833 | £225,234 | 2.99 | 1,650,000 |
| Komata Reefs | r | 1911 | 7,582 | £817 | | 10.62 | |
| Kyshtim Corporation | r | 1910 | 89,509 | £64,335 | | | 1,500,000 |
| La Blanca | o | 10–11 | 67,354 | | | | |
| Lake Copper | z′ | 1909 | 10,124 | | | | |
| Lancaster West | w | 1911 | 258,682 | £33,220 | | 4.88 | |
| Langlaagte Estate | w | 1911 | 625,187 | | £130,425 | 4.36 | 1,281,307 |
| La Rose | s | 1911 | 3,430 | 1,269,086 | 635,000 | 206.61 | 95,914 |
| Le Roi | f | 1909 | 26,534 | — £9,701 | | 15.10 | |
| Le Roi No. 2 | f | 10–11 | 44,619 | £30,176 | £36,000 | 6.68 | |

DATA OF THE WORLD'S PRINCIPAL MINES.—*Continued.*
By S. F. Shaw.

| Name of Mine. | Loc. | Year. | Tonnage Produced. | Profits. | Dividends. | Cost per Ton. | Ore Reserves Tons. |
|---|---|---|---|---|---|---|---|
| Lena Goldfields | *v* | 10–11 | ..... | £333,643 | £336,664 | ..... | ..... |
| Liberty Bell | *z'* | 1910 | 133,899 | $282,147 | £143,606 | $5.27 | ..... |
| Lucky Tiger | *o* | 1911 | 46,945 | 328,846 | 357,601 | 14.37 | 218,315 |
| Luipaardsvlei | *z* | ..... | ..... | ..... | ..... | ..... | 398,000 |
| Main Reef West | *z* | 10–11 | 196,391 | £139,873 | £101,250 | 4.92 | 628,260 |
| Mason and Barry | *x* | 1911 | 412,023 | £59,892 | £55,551 | ..... | ..... |
| May Consolidated | *w* | 1909 | 178,845 | ..... | £115,500 | 4.21 | 400,416 |
| McKinley Darragh-Savage | *s* | 1911 | 60,414 | ..... | 899,075 | ..... | 126,410 |
| Mercur Con | *z'* | 10–11 | 239,190 | $496 | ..... | 2.32 | ..... |
| Mexico Mines of El Oro | *o* | 10–11 | 136,408 | ..... | £144,000 | ..... | 318,720 |
| Meyer and Charlton | *w* | 1911 | 117,154 | £72,092 | £80,000 | 5.74 | 347,040 |
| Miami | *z'* | 1911 | 450,036 | ..... | ..... | 3.75 | 18,232,000 |
| Moctezuma | *o* | 1911 | 517,352 | $1,206,183 | $754,000 | 5.04 | 302,000 |
| Mohawk | *z'* | 1911 | 802,548 | ..... | 175,000 | 1.57 | ..... |
| Montana-Tonopah | *z'* | 10–11 | 52,092 | $172,602 | $120,000 | ..... | ..... |
| Montgomery-Shoshone | *z'* | 1909 | 68,632 | $86,703 | ..... | 4.32 | ..... |
| Morning | *z'* | 1911 | 384,600 | 114,721 | ..... | 4.32 | ..... |
| Mt. Bischoff | *y* | ½–11 | 101,310 | £21,179 | £22,500 | ..... | ..... |
| | | ½–11 | 103,412 | £40,019 | £30,000 | 1.42 | ..... |
| Mt. Boppy | *q* | 1911 | 74,132 | £23,668 | £24,200 | 5.90 | ..... |
| Mt. Elliott | *c* | 10–11 | 42,616 | £130,907 | £73,759 | ..... | 215,000 |
| Mt. Lyell | *y* | ½–11 | 183,094 | £85,775 | £75,000 | 4.87 | ..... |
| Mt. Lyell | *y* | ½–11 | 160,965 | £69,033 | £75,000 | ..... | 3,519,670 |
| Mt. Morgan | *c* | 10–11 | 354,137 | £136,563 | £200,000 | 11.21 | 3,613,500 |
| Mungana | *c* | 1909 | 26,052 | £1,096 | ..... | 9.06 | ..... |
| Mysore | *m* | 1911 | 291,477 | £424,274 | £366,600 | 7.47 | 1,300,369 |
| Nababeep | *w* | 1910 | 54,050 | ..... | ..... | ..... | 219,800 |
| Napa Consolidated | *z* | 1909 | 18,583 | 61,899 | ..... | ..... | ..... |
| Namaqua Copper | *w* | 1911 | 35,506 | £53,319 | £47,165 | ..... | 104,677 |
| Natomas Consolidated | *z'* | 10–11 | 44,542,141 | 2,535,537 | ..... | ..... | 298,453,395 |
| Nevada Consolidated | *z'* | 1911 | 3,338,242 | ..... | 2,957,958 | 2.30 | 40,853,371 |
| New Goch | *w* | 1911 | 346,862 | £115,532 | £68,750 | 4.22 | 894,632 |
| New Heriot | *w* | 1911 | 144,431 | £102,170 | £92,000 | 4.96 | 569,716 |
| New Idria | *z'* | 1909 | 67,247 | $109,639 | $120,000 | ..... | ..... |
| New Kleinfontein | *w* | 1911 | 451,145 | £205,965 | £169,750 | 4.04 | 1,607,015 |
| New Modderfontein | *w* | 10–11 | 538,400 | £294,010 | £297,500 | ..... | 3,452,195 |
| New Primrose | *w* | 1911 | 281,648 | £217,658 | £227,500 | 3.51 | 423,311 |
| New Unified | *w* | 1911 | 122,465 | ..... | ..... | 5.98 | 288,343 |
| New Reitfontein | *w* | 1911 | 180,822 | £39,349 | £30,504 | 5.22 | 361,484 |
| N. Y. & Honduras-Rosario | *l* | 10–11 | 35,813 | ..... | 45,000 | 14.79 | 97,365 |
| Nigel | *w* | 1911 | 134,450 | £48,268 | £33,465 | 5.98 | 190,572 |
| Nipissing | *s* | 1911 | 1,851 | 2,081,710 | 1,842,500 | ..... | ..... |
| North Butte | *z'* | 1911 | 410,694 | 641,858 | 492,000 | 7.57 | 710,920 |
| North Star, Calif | *z'* | 1911 | 95,401 | $419,528 | $425,000 | 5.86 | ..... |
| Nourse | *z'* | 10–11 | 643,675 | £220,319 | £165,564 | 5.40 | 2,050,705 |
| Nundyroog | *m* | 1911 | 102,873 | £140,573 | £127,350 | 9.38 | ..... |
| Old Dominion | *z'* | 1911 | ..... | $621,964 | 436,000 | 4.18 | ..... |
| Ooregum | *m* | 1911 | 152,545 | £138,862 | £120,231 | 6.98 | 186,576 |
| Orientnl Consolidated | *h* | 10–11 | 342,956 | $672,720 | $644,085 | 2.53 | 802,286 |
| Original Con | *z'* | 1909 | 226,492 | $181,359 | ..... | 7.29 | ..... |
| Oroyo-Black Range | *c* | 1910 | 54,180 | £24,516 | £24,986 | 8.39 | ..... |
| Oroya-Links | *c* | 1910 | 100,177 | $125,000 | $71,000 | ..... | ..... |
| Oroville Dredging | *z'* | 1911 | 4,443,262 | 200,454 | ..... | 0.059 | ..... |
| Osceola | *z'* | 1911 | 1,246,596 | $664,628 | $673,050 | 1.37 | ..... |
| Otavi | *z''* | 10–11 | 42,000 | ..... | £224,500 | 5.59 | ..... |
| Ouro Preto | *e* | 10–11 | 69,680 | £4,946 | £6,163 | 6.57 | 170,834 |
| Pahang Cons | *n* | 10–11 | 78,448 | £21,232 | ..... | ..... | ..... |
| Panuco | *o* | 1909 | 13,411 | $238,419 | $212,500 | 4.15 | ..... |
| Penhalonga | *t* | 10–11 | 49,900 | £966 | ..... | 5.19 | ..... |
| Peñoles | *o* | 1909 | 176,616 | $298,570 | $499,200 | 5.58 | ..... |
| Pittsburg Silver Peak | *z'* | 1909 | 150,359 | $337,004 | ..... | ..... | ..... |
| Poderosa | *k* | 1911 | 13,392 | — £16,995 | ..... | 45.58 | 21,000 |
| Portland | *z'* | 10–11 | 67,515 | $307,380 | $240,000 | 14.62 | ..... |
| Prestea Block A | *z''* | 1911 | 93,483 | £2,701 | ..... | 8.19 | 975,101 |
| Princess Estate | *w* | 1911 | 166,628 | £24,215 | £28,751 | 6.55 | 656,500 |
| Progress | *r* | 1911 | 41,596 | ..... | ..... | 9.12 | ..... |
| Quicksilver Mng | *z'* | 10–11 | 24,976 | $22,182 | ..... | 4.99 | ..... |
| Quincy | *z'* | 1911 | 1,382,524 | $507,597 | 440,000 | 1.72 | ..... |
| Randfontein, Central | *w* | 1911 | 2,159,033 | £854,241 | ..... | 4.07 | 5,658,859 |
| Randfontein, South | *w* | 1910 | 1,168,641 | $484,011 | $300,000 | 4.64 | 2,788,099 |
| Rand Mines, Ltd | *w* | 1909 | ..... | ..... | ..... | 4.46 | 4,000,000 |
| Ray Con | *z'* | 1911 | 681,519 | 147,545 | ..... | 3.66 | 77,314,470 |

DATA OF THE WORLD'S PRINCIPAL MINES.—*Continued.*
By S. F. Shaw.

| Name of Mine. | Loc. | Year. | Tonnage Produced. | Profits. | Dividends. | Cost per Ton. | Ore Reserves Tons. |
|---|---|---|---|---|---|---|---|
| Real Del Monte | o | 1909 | 215,209 | | | | |
| Rezende | t | 1910 | 43,800 | £16,624 | | 5.21 | 112,980 |
| Rio Plata | o | 10–11 | 8,775 | | 149,554 | | |
| Rio Tinto | x | 1911 | 2,185,605 | | £1,065,625 | 3.01 | |
| Robinson | w | 1911 | 592,700 | £826,898 | £756,250 | 4.25 | 2,528,794 |
| Robinson Deep | z | 10–11 | 533,850 | £334,379 | | 4.59 | 1,140,000 |
| Roodepoort United | z | 1911 | 366,490 | £73,469 | | 4.29 | 448,000 |
| Rooiberg Min. Dev | w | 10–11 | 17,781 | £52,674 | £13,500 | | 21,650 |
| Rose Deep | w | 1911 | 693,250 | £319,066 | £280,000 | 4.57 | 729,012 |
| Round Mountain | z' | 1910 | 36,252 | $84,313 | $69,322 | 6.17 | 111,928 |
| Salisbury Gold | w | 10–11 | 93,396 | £15,306 | £13,500 | 3.61 | 82,896 |
| San Rafael y Anexas | o | ½–11 | 71,587 | $273,057 | $217,200 | | |
| Santa Gertrudis | o | 10–11 | 101,329 | | | | 630,000 |
| San Toy | o | 1910 | 20,181 | $157,556 | | 25.70 | |
| Selukwe-Columbia | t | 10–11 | 31,535 | £14,965 | £12,500 | 7.94 | 40,000 |
| Seoul Mining | h | 1911 | 70,229 | 263,297 | 200,000 | 3.75 | 211,400 |
| Shannon | z' | 10–11 | 263,975 | 118,854 | | 6.88 | 1,000,000 |
| Shattuck Ariz | z' | 10–11 | 32,029 | $396,687 | 700,000 | 18.00 | |
| Sheba Gold Mining | w | 10–11 | 49,455 | £20,573 | £13,486 | 7.75 | 104,250 |
| Simmer and Jack | w | 10–11 | 811,448 | £526,866 | £600,000 | 3.11 | 2,520,000 |
| Simmer & Jack East | w | 1910 | 365,620 | £63,989 | | 4.33 | 950,000 |
| Simmer Deep | w | 1911 | 539,981 | £56,784 | | 4.05 | 1,312,000 |
| Skidoo | z' | 1909 | 14,726 | 92,617 | 50,000 | 6.55 | |
| Snowstorm | z' | 10–11 | 34,463 | £25,691 | £44,985 | 4.23 | |
| Sons of Gwalia | c | 1911 | 165,644 | | £81,250 | 6.42 | |
| South Crofty | i | 1911 | 63,882 | £31,981 | £17,500 | 5.24 | |
| South Kalgurli | c | 10–11 | 112,170 | £20,465 | £20,000 | 5.35 | 173,200 |
| Spassky Copper | v | 10–11 | 31,302 | £81,846 | £77,000 | | 100,000 |
| Standard Con | z' | 11–12 | 8,798 | | | 17.11 | |
| St. John del Rey | e | 10–11 | 189,600 | | £60,078 | 7.12 | 1,158,560 |
| Stewart | z' | 1910 | 55,347 | | | | |
| Sudan Goldfield | w | 1910 | 14,662 | — £6,227 | | 10.31 | 6,010 |
| Sulphide Corp | c | 10–11 | 226,768 | £179,448 | £144,375 | 17.65 | |
| Suberior | z' | 1911 | 162,599 | — $51,989 | | 2.97 | |
| Superior & Pittsburg | z' | 1909 | 251,042 | | | 10.81 | |
| Surprise | t | 1909 | 29,643 | — £6,835 | | 6.50 | |
| Talisman Con | r | 10–11 | 45,850 | £110,307 | £100,447 | 10.38 | |
| Tamarack | z' | 1910 | 525,554 | — $191,345 | | 2.67 | |
| Taquah Mining & Exp | z'' | 10–11 | 12,387 | | | | 95,790 |
| Tasmania Gold Mng | y | 10–11 | 53,968 | £4,020 | | 9.16 | 43,084 |
| Temiskaming | s | 10–11 | 11,785 | 288,972 | 181,507 | | |
| Tennessee Copper | z' | 1911 | 436,285 | 407,049 | 300,000 | | |
| Tharsis Sulphur | x | 1911 | 327,348 | £188,139 | £187,500 | | |
| Thistle-Etna | t | 1910 | 37,261 | £1,426 | | 5.55 | |
| Tilt Cove | p | 10–11 | 29,077 | £4,733 | | | 40,000 |
| Tincroft | i | ½–09 | 36,825 | | | | |
| Tomboy | z' | 10–11 | 116,222 | $272,267 | £60,000 | 4.37 | 427,000 |
| Tombstone, Con | z' | 1909 | 15,070 | | | | |
| Tonapah Belmont | z' | 1911 | 115,563 | $1,500,000 | | | 348,912 |
| Tonopah Mining | z' | 11–12 | 174,685 | | 1,600,000 | | 304,824 |
| Treasury Gold | z | 10–11 | 64,230 | £16,482 | | 5.06 | 250,000 |
| Trenton | z' | 1909 | 157,167 | 165,110 | 470,000 | 7.04 | |
| Trethewey | s | 1911 | | 160,318 | 200,000 | | |
| Tri-Mountain | z' | 1911 | 734,392 | 454,589 | 500,000 | 2.05 | |
| Troitsk Goldfield | v | 10–11 | 40,628 | — £8,945 | | 6.20 | |
| Tronoh | n | 1911 | 461,025 | £185,548 | £136,000 | | |
| Tuolumne | z' | 1911 | 30,499 | | 360,000 | | |
| Tkee Copper | f | 1910 | 45,760 | £1,200 | | | |
| U. S. S. R. & Mng. Co | z' | 1911 | 1,037,685 | | 2,404,669 | | |
| Utah Apex | z' | 1908 | 33,407 | $124,185 | | | 80,000 |
| Utah Con | z' | 1911 | 170,527 | $438,429 | $150,000 | 6.50 | 263,438 |
| Utah Copper | z' | 1911 | 4,680,801 | 4,470,933 | 4,703,022 | 1.78 | 229,830,00 |
| Van Roi | f | 1911 | 22,427 | — £2,661 | | | |
| Van Ryn | w | 10–11 | 396,950 | £210,847 | £225,000 | 4.36 | 1,655,910 |
| Village Deep | w | 1910 | 508,540 | £154,067 | £106,067 | 4.45 | 1,704,226 |
| Village Main Reef | w | 1911 | 474,135 | £404,196 | £330,400 | 4.97 | 1,814,754 |
| Vindicator | z' | 1911 | 30,233 | $238,804 | | 15.47 | |
| Vivian Gold Mining | c | 1909 | 41,149 | £2,241 | | 5.60 | 35,216 |
| Vogelstruis Est | z | 10–11 | 101,033 | — £18,074 | | 7.62 | 147,815 |
| Waihi | r | 1911 | 350,699 | £332,857 | £272,748 | 4.80 | 1,534,826 |
| Waihi Grand Jc | r | 1911 | 105,956 | £25,949 | £19,218 | 5.80 | 198,350 |
| Wanderer | t | 10–11 | 195,234 | $15,190 | | 2.22 | 424,195 |
| Washoe | z' | 1909 | 205,377 | | | | |

DATA OF THE WORLD'S PRINCIPAL MINES.—*Continued.*
By S. F. Shaw.

| Name of Mine. | Loc. | Year. | Tonnage Produced. | Profits. | Dividends. | Cost per Ton. | Ore Reserves Tons. |
|---|---|---|---|---|---|---|---|
| West End Con..... | *z'* | 10–11 | 16,164 | 42,490 | ..... | $18.29 | ..... |
| West Rand Prop ..... | *w* | 1911 | 319,640 | £48,905 | ..... | ..... | 1,003,000 |
| Wheal Kitty..... | *i* | 1911 | 7,816 | ..... | ..... | 6.98 | ..... |
| Witwatersrand Deep .... | *w* | 1911 | 500,330 | £301,542 | £192,500 | 4.19 | 1,436,202 |
| Witwatersrand Gold .... | *w* | 1911 | 416,741 | £151,299 | £148,750 | 3.40 | 1,225,082 |
| Wolhuter..... | *w* | 1910 | 304,360 | £122,554 | £86,000 | 4.26 | 753,679 |
| Wolverine ..... | *z'* | 10–11 | 388,476 | $485,705 | $600,000 | 1.64 | ..... |
| Worchester Expl. & Gold | *w* | 1910 | 55,330 | £25,177 | £16,751 | 3.87 | ..... |
| Yukon Gold ..... | *a* | 1911 | 6,276,800 | ..... | 1,312,500 | ..... | ..... |
| Zinc Corporation ..... | *z'''* | 1910 | 204,683 | £73,243 | £24,569 | 5.44 | 3,000,000 |

*Note.*—*a*, Alaska; *b*, Argentina; *c*, Australia; *d*, Bolivia; *e*, Brazil; *f*, British Columbia; *g*, Burma; *h*, Korea; *i*, Great Britain; *j*, Costa Rica; *k*, Chile; *l*, Honduras; *m*, India; *n*, Malay States; *o*, Mexico; *p*, Newfoundland; *q*, New South Wales; *r*, New Zealand; *s*, Ontario; *t*, Rhodesia; *u*, Salvador; *v*, Siberia; *w*, South Africa; *x*, Spain; *y*, Tasmania; *z*, Transvaal; *z'*, United States; *z''*, West Africa; *z'''*, Yukon.

The above tabulation of data obtained from abstracts of annual mining reports published in the principal mining magazines, was compiled for the purpose of securing relative data on the costs of production of the various metal-mining companies operating in different parts of the world.

It will be seen that English companies form a large percentage of those enumerated, as there is a greater tendency for these companies to make public the items of production, cost, ore reserves, etc., than is the case with American companies.

These data cover for the most part the calendar and fiscal years ending in 1910 and 1911.

The column headed "tonnage produced" refers to the tons of ore actually shipped to the smeltery or treated locally and does not include waste which was sorted out of the ore hoisted. It is customary among the Rand mines to note the amount of waste so hoisted and sorted out, but this applies to but few American mines.

Where sufficient data were given to enable it to be done, the profits are figured as the amount remaining after all expenses of operation, administration, depreciation, development, taxes, etc., were paid. Such money as was put into the capital account, however, is not included.

In figuring the cost per ton, all items in the nature of expenses of operation, administration, depreciation, etc., are included exactly as in the case of computing the profits.

The reserves are, of course, those given in the official report as the number of tons of ore remaining blocked out at the end of the year under review. Probable ore is not so included, neither is that portion of the vein which, though blocked out, is too low grade to return a profit.

# AUSTRALASIA

In the following tables the production of minerals and metals in each of the Australian States and New Zealand is separately itemized. In the tables relating to foreign commerce, however, the States are not separately treated, the combined statistics of the Commonwealth now being officially reported.

MINERAL PRODUCTION OF NEW SOUTH WALES. (*a*)
(In metric tons or dollars; £1 = $5.) (*b*)

| Year. | Alunite. | Antimony and Ore. | Bismuth Ore. | Chrome Ore. | Coal. | Coke. | Cobalt Ore. | Copper Ore. |
|---|---|---|---|---|---|---|---|---|
| 1898..... | 2,988 | 83 | 29 | 2,145 | 4,781,551 | 83,538 | 119 | 181 |
| 1899..... | 935 | 332 | 16 | 5,327 | 4,670,580 | 98,074 | 193 | 445 |
| 1900..... | 1,946 | 252 | 11 | 3,338 | 5,595,879 | 128,238 | 145 | 867 |
| 1901..... | 3,196 | 90 | 21 | 2,523 | 6,063,921 | 130,944 | 112 | 655 |
| 1902..... | 3,702 | 58 | 10 | 508 | 6,037,083 | 128,902 | 35 | 3,190 |
| 1903..... | 2,524 | 13 | 23 | 1,982 | 6,456,523 | 163,161 | 155 | 1,750 |
| 1904..... | 376 | 111 | 41 | 404 | 6,116,126 | 173,742 | 6 | 2,470 |
| 1905..... | 2,745 | 394 | 56 | 53 | 6,738,252 | 165,568 | *Nil.* | 487 |
| 1906..... | 1,886 | 2,490 | 25 | 15 | 7,748,384 | 189,038 | *Nil.* | (*g*) |
| 1907..... | 2,021 | 1,780 | 17 | 30 | 8,796,451 | 258,683 | *Nil.* | (*g*) |
| 1908..... | 1,099 | 119 | 9 | *Nil.* | 9,293,377 | 288,413 | *Nil.* | (*g*) |
| 1909..... | 3,556 | 97 | 9 | *Nil.* | 7,132,548 | 207,553 | *Nil.* | (*g*) |
| 1910..... | 1,154 | 99 | 7 | *Nil.* | 8,304,693 | 286,854 | 10 | (*g*) |
| 1911..... | 1,023 | 168 | 9 | *Nil.* | 8,831,175 | 268,935 | *Nil.* | (*g*) |
| 1912..... | 3,479 | 64 | 6 | *Nil.* | 10,044,487 | 245,050 | *Nil.* | (*g*) |

| Year. | Copper Matte, Ingot and Regulus. | Diamonds. *Karats.* | Gold. (*b*) | Lead, Argentiferous. (*f*) | | Lead. Pig. (*f*) | Molybdenite. | Opal. |
|---|---|---|---|---|---|---|---|---|
| | | | | Ore. | Metal. (*e*) | | | |
| 1898.... | 5,577 | 16,493 | $5,847,680 | 394,676 | 10,270 | 1,745 | ..... | $400,000 |
| 1899.... | 5,574 | 25,874 | 7,899,075 | 431,126 | 20,614 | (*d*)4,896 | ..... | 675,000 |
| 1900.... | 6,243 | 9,828 | 5,211,097 | 426,480 | 19,400 | (*d*)6,807 | ..... | 400,000 |
| 1901.... | 6,184 | 9,322 | 3,587,040 | 406,560 | 17,191 | (*d*)3,394 | ..... | 600,000 |
| 1902.... | 5,560 | 11,995 | 3,333,064 | 371,496 | 15,660 | (*d*)4,685 | 16 | 700,000 |
| 1903.... | 8,094 | 12,239 | 5,255,421 | 335,870 | 18,779 | (*d*)3,561 | 31 | 500 000 |
| 1904.... | 6,654 | 14,296 | 5,576,966 | 373,362 | 30,212 | (*d*)5,977 | 26 | 285,000 |
| 1905.... | 7,899 | 6,354 | 5,669,099 | 420,266 | 28,244 | 214 | 20 | 295,000 |
| 1906.... | 9,911 | 2,827 | 5,249,762 | 377,890 | 22,573 | 60 | 34 | 282,500 |
| 1907.... | 10,260 | 2,539 | 5,112,852 | 441,024 | 20,687 | 20,084 | 22 | 395,000 |
| 1908.... | 9,215 | 2,205 | 4,646,451 | 364,488 | (*h*) | 15,174 | 9 | 209,000 |
| 1909.... | 7,078 | 5,474 | 4,231,211 | 273,628 | (*h*) | 15,724 | 29 | 309,000 |
| 1910.... | 13,096 | 3,606 | 4,011,055 | 322,780 | (*h*) | 21,534 | 50 | 331,000 |
| 1911.... | 12,295 | 5,771 | 3,743,672 | 343,902 | (*h*) | 17,552 | 21 | 286,500 |
| 1912.... | 11,211 | 2,239 | 3,416,560 | 350,850 | (*h*) | 17,528 | 57 | 170,349 |

| Year. | Platinum. Kg. | Shale Oil. | Silver—Kg. (f) | Tin. | | Tungsten Ore. | Zinc. (c) (f) |
|---|---|---|---|---|---|---|---|
| | | | | Ore. | Block. | | |
| 1898..... | 38.9 | 30,164 | 16,580 | 1 | 639 | ..... | 39,564 |
| 1899..... | 19.8 | 37,307 | 21,525 | 5 | 749 | ..... | 50,677 |
| 1900..... | 15.6 | 23,229 | 24,080 | 15 | 1,087 | ..... | 20,594 |
| 1901..... | 12.1 | 55,650 | 13,950 | 11 | 659 | ..... | 642 |
| 1902..... | 11.6 | 63,886 | 33,195 | 23 | 502 | ..... | 1,281 |
| 1903..... | 16.5 | 35,332 | 34,195 | 556 | 949 | 9 | 21,086 |
| 1904..... | 16.6 | 38,477 | 34,880 | 586 | 1,084 | 106 | 58,523 |
| 1905..... | 12.4 | 38,838 | 12,987 | 726 | 817 | 228 | 105,189 |
| 1906..... | 6.4 | 32,965 | 8,865 | (h) | 1,698 | 245 | 105,325 |
| 1907..... | 8.6 | 48,088 | 63,573 | (h) | 1,945 | 409 | 241,015 |
| 1908..... | 4.2 | 47,044 | 77,490 | (h) | 1,822 | 247 | 281,147 |
| 1909..... | 13.7 | 49,500 | 53,430 | (h) | 1,974 | 129 | 379,907 |
| 1910..... | 10.3 | 69,385 | 55,176 | (h) | 1,898 | 168 | 476,125 |
| 1911..... | 14.6 | 76,306 | 54,975 | (h) | 1,960 | 288 | 524,666 |
| 1912..... | 19.0 | 87,399 | 74,314 | (h) | 2,107 | 231 | 528,872 |

(a) From the Annual Report of the Department of Mines, New South Wales. (b) Where gold is reported £1 = $4.866. (c) Spelter and concentrate. (d) Includes minor quantities of lead carbonate and chloride, the product of the leaching plant at Broken Hill. (e) Includes a small quantity of silver-sulphide. (f) Exported. In the case of lead, 101,811 long tons were produced in 1912 from N. S. Wales in Australia; see article on lead. (g) Included with metal. (h) Included with ore.

MINERAL PRODUCTION OF QUEENSLAND. (a)

(In metric tons or dollars; £1 = $5.)

| Year. | Bismuth Ore. | Coal. | Copper. | Gold (b). | Lead. | Manganese Ore. |
|---|---|---|---|---|---|---|
| 1898..... | 8 | 414,461 | 63 | $19,016,763 | 252 | 68 |
| 1899..... | 2 | 501,913 | 164 | 19,571,662 | 57 | 747 |
| 1900..... | 8 | 505,252 | 386 | 20,002,290 | 207 | 77 |
| 1901..... | 20 | 548,104 | 3,110 | 12,367,276 | 570 | 221 |
| 1902..... | 1 | 509,579 | 3,845 | 13,238,500 | 271 | 4,674 |
| 1903..... | 11 | 515,950 | 4,995 | 13,818,653 | 3,856 | 1,341 |
| 1904..... | 20 | 520,232 | 4,440 | 13,210,869 | 2,079 | 843 |
| 1905..... | 15 | 537,795 | 7,337 | 12,249,157 | 2,464 | 1,541 |
| 1906..... | 7 | 610,480 | 10,238 | 11,257,316 | 2,854 | 1,131 |
| 1907..... | 6 | 694,204 | 12,959 | 9,641,789 | 5,240 | 1,134 |
| 1908..... | 22 | 707,473 | 14,932 | 9,613,051 | 7,207 | 1,403 |
| 1909..... | 11 | 768,720 | 14,727 | 9,416,576 | 5,323 | 613 |
| 1910..... | 22 | 885,108 | 16,649 | 9,123,531 | 2,435 | 805 |
| 1911..... | 10 | 905,568 | 20,709 | 7,981,791 | 1,799 | 1,167 |
| 1912..... | 6 | 916,646 | 23,491 | 7,191,846 | 3,158 | ..... |

| Year. | Molybdenite. | Opal. | Silver. Kg. | Tin Ore. | Tungsten Ore. |
|---|---|---|---|---|---|
| 1898..... | ..... | $33,225 | 3,235 | 1,041 | 79 |
| 1899..... | ..... | 45,000 | 4,521 | 1,322 | 263 |
| 1900..... | ..... | 37,500 | 3,514 | 1,133 | 193 |
| 1901..... | ..... | 37,000 | 17,777 | 1,638 | 73 |
| 1902..... | (c) 42 | 35,000 | 21,813 | 2,118 | 56 |
| 1903..... | (c) 24 | 36,500 | 19,972 | 3,768 | 200 |
| 1904..... | (c) 22 | 17,750 | 20,370 | 3,986 | 1,564 |
| 1905..... | 64 | 15,000 | 18,716 | 4,008 | 1,434 |
| 1906..... | 108 | 15,000 | 24,357 | 4,900 | 785 |
| 1907..... | 68 | 15,000 | 28,662 | 5,222 | 627 |
| 1908..... | 89 | 12,500 | 36,200 | 4,903 | 426 |
| 1909..... | 94 | 10,000 | 31,140 | 3,379 | 617 |
| 1910..... | 108 | 15,000 | 26,787 | 3,000 | 869 |
| 1911..... | (c)232 | 15,000 | 17,076 | 3,140 | 548 |
| 1912..... | (c)298 | 15,000 | 17,704 | 3,281 | 642 |

(a) From *Annual Reports* of the Under Secretary of Mines, Queensland. (b) Where gold is reported £1 = $4.866. (c) Includes bismuth and tungsten.

MINERAL PRODUCTION OF SOUTH AUSTRALIA.
(In metric tons or dollars; £1 = $5.) (b)

| Year. | Copper. | | Gold. (b) | Iron Ore. | Lead. | Lime-stone. | Phosphate Rock. | Salt. | Other Metals and Minerals. |
|---|---|---|---|---|---|---|---|---|---|
| | Ore. | Metal. | | | | | | | |
| 1899..... | 2,938 | 5,584 | $75,822 | ..... | 370 | ..... | ..... | ..... | $6,785 |
| 1900..... | 2,405 | 4,964 | 70,528 | ..... | 389 | ..... | ..... | ..... | 2,055 |
| 1901..... | 1,896 | 6,844 | 80,839 | ..... | 69 | ..... | ..... | ..... | 11,095 |
| 1902..... | 2,620 | 6,956 | 121,056 | ..... | 2,210 | ..... | ..... | ..... | 3,710 |
| 1903..... | 7,182 | 6,594 | 139,411 | 86,291 | 732 | ..... | 1,016 | 40,640 | 500 |
| 1904..... | 3,100 | 6,378 | 369,938 | 47,434 | ..... | 44,135 | 3,048 | 40,640 | 990 |
| 1905..... | 2,604 | 6,653 | 223,121 | 85,835 | 53 | 45,210 | 5,080 | 33,020 | 6,305 |
| 1906..... | 535 | 8,339 | 131,382 | 76,430 | 51 | 32,451 | 5,944 | 55,880 | 11,045 |
| 1907..... | ..... | 8,058 | 99,948 | 85,954 | ..... | 31,598 | 8,128 | 76,200 | 12,500 |
| 1908..... | ..... | 5,718 | 59,852 | 89,412 | ..... | 29,973 | 11,177 | 76,204 | 22,500 |
| 1909..... | 1,250 | 5,788 | 146,982 | 16,379 | 142 | 13,986 | 3,833 | 52,232 | 19,365 |
| 1910..... | ..... | 5,184 | 136,248 | 46,939 | 406 | 18,898 | 5,283 | 54,862 | 68,000 |
| 1911 (a).. | ..... | 6,017 | 72,990 | 42,976 | ..... | 29,159 | 5,893 | 66,040 | 56,600 |
| 1912..... | ..... | 6,395 | 136,248 | 42,877 | ..... | 51,412 | 6,198 | 65,338 | 51,044 |

(a) From *Review of Mining Operations* by Hon. Richard Butler, Adelaide, 1911. (b) Where gold is reported, £1 = $4.866.

MINERAL PRODUCTION OF TASMANIA. (a)
(In metric tons or dollars; £1 = $5.) (b)

| Year. | Coal. | Copper Ore. | Blister Copper. | Gold. (b) | Iron Ore. | Lead-Silver Ore. | Tin Ore. |
|---|---|---|---|---|---|---|---|
| 899..... | 43,803 | (d) | (d) | $1,593,834 | 6,726 | 424,552 | 3,333 |
| 1900..... | 51,549 | 4,221 | 9,343 | 1,538,727 | 5,141 | 453,519 | 2,693 |
| 1901..... | 49,963 | 11,401 | 10,141 | 1,436,326 | 1,422 | 804,463 | 2,516 |
| 1902..... | 49,647 | 8,630 | 7,869 | 1,467,454 | 2,424 | 47,226 | 1,989 |
| 1903..... | 49,856 | 3,891 | 6,791 | 1,237,925 | 6,076 | 43,103 | 2,414 |
| 1904..... | 62,090 | (d) | 8,826 | 1,362,587 | 6,950 | 51,959 | 2,104 |
| 1905..... | 52,825 | (d) | 9,919 | 1,520,101 | 6,401 | 76,424 | 3,953 |
| 1906..... | 53,742 | 2,270 | 8,847 | 1,240,650 | 2,642 | 88,513 | 4,545 |
| 1907..... | 59,833 | 1,261 | 8,378 | 1,350,836 | 3,048 | 91,216 | 4,412 |
| 1908..... | 62,044 | 1,204 | 8,974 | 1,179,950 | 3,657 | 62,022 | 4,593 |
| 1909..... | 67,224 | 1,613 | 8,472 | 951,005 | *Nil.* | 81,668 | 4,583 |
| 1910..... | 83,763 | 682 | 8,324 | 765,784 | *Nil.* | 52,047 | 3,760 |
| 1911..... | 57,980 | 2,323 | 6,118 | 628,375 | *Nil.* | 62,489 | 4,016 |
| 1912..... | 54,366 | 1,414 | 5,218 | 784,320 | *Nil.* | 91,570 | 3,773 |

(a) From *Statistics of the Colony of Tasmania.* (b) Where value of gold is reported, £1 = $4.866 (c) Included with lead-silver ore. (d) Not reported.

MINERAL PRODUCTION OF NEW ZEALAND. (a) (b)
(In metric tons or dollars.) (c)

| Year. | Anti-mony. | Chrome Ore. | Coal. | Coke. | Copper Ore | Gold. (c) | Kauri-gum. | Manga-nese Ore. | Silver. Kg. |
|---|---|---|---|---|---|---|---|---|---|
| 1899... | ..... | ..... | 990,886 | 18 | ..... | $7,363,100 | 11,294 | 137 | 10,865.6 |
| 1900... | 3 | 28 | 1,111,860 | ..... | 12 | 7,005,103 | 10,322 | 166 | 10,202.0 |
| 1901... | 30 | ..... | 1,247,341 | ..... | 3 | 8,533,908 | 7,662 | 211 | 17,762.0 |
| 1902... | ..... | 128 | 1,383,511 | ..... | ..... | 9,495,673 | 7,549 | ..... | 20,970.3 |
| 1903... | ..... | ..... | 1,442,987 | ..... | 6 | 9,916,086 | 9,507 | 71 | 28,364.3 |
| 1904... | ..... | ..... | 1,562,520 | ..... | ..... | 9,671,180 | 9,203 | 196 | 34,042.3 |
| 1905... | ..... | ..... | 1,611,207 | 15 | 4 | 10,189,093 | 10,883 | 55 | 36,695.0 |
| 1906... | ..... | ..... | 1,757,284 | 5 | ..... | 11,050,219 | 9,300 | 16 | 43,251.5 |
| 1907... | 100 | ..... | 1,860,397 | 15 | 57 | 9,865,766 | 8,847 | 5 | 48,603.5 |
| 1908... | 5 | ..... | 1,890,844 | 2 | 13 | 9,755,303 | 5,618 | *Nil.* | 53,834.8 |
| 1909... | 2 | *Nil.* | 1,941,923 | 23 | 5 | 9,765,575 | 8,382 | 6 | 56,410.0 |
| 1910... | *Nil.* | *Nil.* | 2,232,610 | *Nil.* | *Nil.* | 9,227,532 | 8,832 | 5 | 52,176.8 |
| 1911... | 20 | *Nil.* | 2,099,234 | *Nil.* | *Nil.* | 9,105,000 | 7,608 | 1 | 40,775.2 |
| 1912... | ..... | ..... | (d)231,781 | 4 | *Nil.* | 6,427,422 | 8,035 | ..... | 24,237.8 |

(a) From New Zealand Mines Statement, by the Hon. Roderick McKenzie, Minister of Mines, Wellington. (b) The exports are stated to be identical with the production, with the exception of coal. (c) Where gold is reported £1 = $4.866. (d) Exports.

MINERAL PRODUCTION OF VICTORIA. (a)
(In metric tons or dollars.)

| Year. | Coal. | Lignite. | Gold. (c) | Building Stone, etc. | Tin Ore. |
|---|---|---|---|---|---|
| 1898..... | 246,845 | 2,915 | $17,305,547 | $100,000 | 87 |
| 1899..... | 266,578 | (b) | 17,662,410 | (b) | 158 |
| 1900..... | 215,052 | (b) | 16,767,261 | 175,000 | 71 |
| 1901..... | 212,678 | 152 | 16,320,029 | 225,000 | 78 |
| 1902..... | 228,777 | (b) | 14,899,876 | 266,975 | 10 |
| 1903..... | 65,230 | 5,752 | 15,860,815 | 213,245 | 34 |
| 1904..... | 123,695 | *Nil.* | 15,824,952 | 1,488,075 | 72 |
| 1905..... | 157,648 | *Nil.* | 15,443,438 | (b) | 126 |
| 1906..... | 163,201 | *Nil.* | 15,962,804 | (f) 362,725 | 108 |
| 1907..... | 140,802 | *Nil.* | 14,377,166 | (f) 401,090 | 105 |
| 1908..... | 115,283 | *Nil.* | 13,867,312 | (f) 453,075 | 80 |
| 1909..... | 130,230 | *Nil.* | 13,522,400 | 397,645 | 90 |
| 1910..... | 374,775 | 660 | 11,789,077 | 574,775 | 42 |
| 1911..... | 664,326 | 6,232 | 11,789,077 | 75,063 | 33 |
| 1912..... | 598,599 | 4,076 | 9,924,032 | ..... | 48 |

(a) From annual Reports of the Secretary for Mines of the Colony. (b) Not reported. (c) Where gold is reported, £1 = $4.866. (e) Estimated value. (f) Includes crude salt.

MINERAL PRODUCTION OF WESTERN AUSTRALIA. (a)
(In metric tons or dollars.)

| Year. | Tungsten Ore. | Coal. | Copper Ore. | Copper and Matte. | Gold. (b) (c) | Iron Ore. | Lead Ore. | Silver. *Kg.* | Tin Ore. |
|---|---|---|---|---|---|---|---|---|---|
| 1902..... | ..... | 143,145 | 2,298 | ..... | $37,026,119 | 4,877 | (d) 36 | 2,590 | 630 |
| 1903..... | ..... | 135,568 | 20,854 | ..... | 40,560,927 | 224 | *Nil.* | 5,229 | 830 |
| 1904..... | ..... | 140,773 | 4,033 | ..... | 39,557,933 | 1,465 | *Nil.* | 12,416 | 869 |
| 1905..... | ..... | 129,402 | 2,389 | ..... | 38,045,366 | 3,264 | *Nil.* | 11,189 | 1,096 |
| 1906..... | ..... | 152,151 | 7,548 | (f)3,676 | 35,888,278 | 1,300 | *Nil.* | 8,776 | 1,518 |
| 1907..... | ..... | 144,651 | 19,282 | 1,628 | 35,087,500 | 1,112 | (d) 214 | 5,887 | (e) 1,526 |
| 1908..... | ..... | 178,061 | 8,427 | 486 | 34,061,426 | *Nil.* | (d) 526 | 5,240 | (e) 1,111 |
| 1909..... | 1 | 217,741 | 7,071 | 846 | 32,973,349 | *Nil.* | (d) 214 | 5,500 | (e) 709 |
| 1910..... | 2 | 266,361 | 6,410 | 1,301 | 30,397,162 | 10 | 252 | 5,478 | 508 |
| 1911..... | 10 | 253,900 | 9,974 | 832 | 28,331,272 | *Nil.* | 884 | 5,215 | 503 |
| 1912..... | *Nil.* | 299,815 | 13,825 | 1,730 | 26,511,840 | *Nil.* | 11,276 | 4,293 | 563 |

(a) From the *Report of the Department of Mines of Western Australia.* (b) £1 = $4.866. (c) The value of gold produced in 1895 was $4,280,855; in 1896, $5,200,821; in 1897, $12,481,176; in 1898, $19,418,735; in 1899, $30,396,593; in 1900, $27,461,865. (d) Silver-lead and lead ore. (e) Includes ingots. (f) Total in previous years.

MINERAL IMPORTS OF AUSTRALIA. (a)
(In metric tons, cwts. of 112 lb., or dollars; £1 = $5.) (b)

| Year. | Cement. *Cwts.* | Coal. | Coke. | Copper Ore. *Cwts.* | Gold. (b) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Ore. | Bullion. | Specie. | Foil. (c) | Total Value |
| 1902 | 1,074,482 | 5,149 | 9,846 | 29,236 | $2,375,513 | $3,834,510 | $505,899 | $30,028 | $6,740,950 |
| 1903 | 954,606 | 389 | 4,294 | 5 | 66,908 | 5,935,800 | 6,530 | 38,680 | 6,047,918 |
| 1904 | 561,237 | 398 | 4,270 | 12 | 68,309 | 5,684,164 | 6,297 | 43,215 | 5,801,985 |
| 1905 | 700,245 | 7,866 | 5,553 | 80 | 103,709 | 7,067,534 | 422,127 | 52,144 | 7,645,514 |
| 1906 | 793,928 | 706 | 6,202 | 873 | 93,116 | 10,053,463 | 397,990 | 53,356 | 10,597,925 |
| 1907 | 513,326 | 14,973 | 9,981 | 3,652 | 136,520 | 6,942,940 | 48,499 | 45,283 | 7,173,242 |
| 1908 | 915,033 | 14,833 | 10,368 | 3,959 | 42,855 | 4,625,498 | 70,197 | ..... | 4,738,550 |
| 1909 | 848,337 | 16,044 | 44,668 | 4,533 | 36,670 | 4,865,436 | 56,280 | 118,240 | 5,076,626 |
| 1910 | 1,612,004 | 314,374 | 17,161 | 23,027 | 35,991 | 4,634,553 | 126,556 | ..... | (e)4,816,100 |
| 1911 | 1,670,117 | 10,498 | 22,608 | 10,201 | 59,613 | 7,707,920 | 124,248 | ..... | 7,891,781 |
| 1912 | 2,603,792 | 16,152 | 15,839 | 18,449 | 93,885 | 5,478,177 | 1,190,890 | ..... | 6,762,952 |

| Year. | Graphite Cwts. | Iron and Steel. Bars, Rods Girders, Sheets etc. Cwts. | Iron and Steel. Galvanized Plates and Sheets. Cwts. | Iron and Steel. Pig and Scrap. Cwts. | Lead Mfrs. Cwts. | Petroleum Products. Kerosene. Gal. | Petroleum Products. Naphtha Gal. | Petroleum Products. Paraffin. |
|---|---|---|---|---|---|---|---|---|
| 1902.. | 2,659 | ..... | 1,104,701 | 766,725 | 8,300 | 10,399,931 | 116,170 | 1,913 |
| 1903.. | 5,557 | 1,211,437 | 886,570 | 989,998 | 9,525 | 15,009,609 | 127,445 | 2,163 |
| 1904.. | 4,263 | 1,399,783 | 1,027,859 | 883,397 | 6,243 | 14,791,319 | 277,737 | 530 |
| 1905.. | 4,386 | 1,482,334 | 1,112,467 | 940,757 | 8,859 | 16,416,734 | 292,670 | ..... |
| 1906.. | 6,531 | 1,878,851 | 1,245,211 | 1,220,236 | 14,830 | 15,473,570 | 488,961 | ..... |
| 1907.. | 6,991 | 2,045,184 | 1,502,790 | 1,276,566 | 2,940 | 19,273,955 | 683,679 | 2,578 |
| 1908.. | ..... | 2,153,528 | (d)1,253,624 | 820,834 | 2,703 | 17,154,940 | 782,859 | 1,560 |
| 1909.. | ..... | 2,559,798 | (d)1,658,291 | 1,178,219 | 19,338 | 19,924,622 | 884,703 | 2,767 |
| 1910.. | £9,951 | 3,663,386 | 2,131,911 | 1,073,933 | 9,111 | 19,660,890 | 1,339,381 | 3,963 |
| 1911.. | £7,782 | 4,212,986 | 2,177,961 | 1,574,439 | 1,820 | 19,378,540 | 1,772,840 | 3,314 |
| 1912.. | £8,629 | 4,933,414 | 2,416,367 | 1,719,585 | 1,194 | 24,292,539 | 12,294,617 | 2,832 |

| Year. | Potassium Nitrate. Cwts. | Quick-silver. | Salt. Cwts. | Silver. (b) Ore. Cwts. | Silver. (b) Bullion. Kg. | Silver. (b) Specie. | Sulphur. Cwts. | Spelter, Sheets, Concentrates, Dross, etc. Cwts. |
|---|---|---|---|---|---|---|---|---|
| 1902..... | 7,955 | 92.6 | 571,548 | 5,562 | 13.6 | 439,186 | 173,176 | 20,965 |
| 1903..... | 4,659 | 87.5 | 312,681 | ..... | 14.2 | 160,111 | 180,719 | 14,197 |
| 1904..... | 7,812 | 92.6 | 355,599 | ..... | 39.8 | 154,534 | 252,744 | 23,316 |
| 1905..... | 9,010 | 82.1 | 492,727 | ..... | 3908.0 | 261,397 | 177,304 | 26,211 |
| 1906..... | 8,112 | 78.6 | 326,042 | 380 | 9756.4 | 703,820 | 269,704 | 24,233 |
| 1907..... | 8,571 | 59.5 | 409,852 | 2 | 11.4 | 1,829,309 | 264,060 | 24,026 |
| 1908..... | 6,036 | 56.4 | 390,535 | ..... | 189.8 | 1,019,738 | 420,098 | 38,724 |
| 1909..... | 6,894 | 58.1 | 234,092 | ..... | 622.1 | 157,352 | 405,396 | 59,475 |
| 1910..... | 7,016 | 57.0 | 444,081 | 14,609 | 1,412.0 | 1,615,775 | 357,332 | 70,658 |
| 1911..... | 10,257 | 41.5 | 753,849 | 17,340 | 1,580.3 | 1,647,830 | 386,764 | 86,601 |
| 1912..... | 10,127 | 53.0 | 475,967 | 3,863 | 1,580.3 | 1,350,870 | 465,643 | 29,245 |

(a) From Trade and Customs Returns, Commonwealth of Australia. Previous to 1900 each Colony reported its own imports and exports. (b) Where gold or silver values are reported, £1 = $4.866. (c) Includes silver and other foils. (d) Includes ungalvanised corrugated. (e) Includes $19,000 in matte

## MINERAL EXPORTS OF AUSTRALIA. (a)

(In metric tons, cwts. of 112 lb., or dollars; £1 = $5.)

| Year. | Alunite. Cwts. | Antimony Ore. Cwts. | Bismuth Ore. Cwts. | Cement. Cwts. | Chrome Ore. Cwts. | Coal. | Coke. | Cobalt Ore. Cwts. | Copper. Ore. Cwts. | Copper. Ingot and Matte. (Cwts.) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1902. | 72,880 | 1,428 | 136 | ..... | 10,000 | 1,687,621 | 6,080 | 748 | 165,149 | 464,715 |
| 1903. | 49,690 | 947 | 832 | 11,168 | 39,022 | 2,063,016 | 27,345 | 3,060 | 61,569 | 616,277 |
| 1904. | 7,400 | 2,177 | 1,918 | 26,305 | 7,941 | 1,637,113 | 2,771 | 167 | 90,098 | 540,998 |
| 1905. | 54,040 | 7,811 | 2,222 | 17,283 | (c) | 2,058,190 | 2,316 | 1,320 | 17,380 | 632,183 |
| 1906. | 37,120 | 66,188 | 1,574 | 39,737 | (c) | 2,094,793 | 11,382 | ..... | 33,476 | 744,357 |
| 1907. | 41,750 | 74,440 | 653 | 75,600 | 54,503 | 2,689,917 | 35,063 | ..... | 157,071 | 853,236 |
| 1908. | 21,640 | 23,931 | 1,396 | 49,116 | 22,300 | 2,601,944 | 28,068 | ..... | 103,694 | 765,298 |
| 1909. | 73,795 | 14,976 | 1,763 | 23,585 | ..... | 1,608,161 | 24,798 | 280 | 163,612 | 676,664 |
| 1910. | 23,290 | 12,796 | 1,456 | 34,259 | ..... | 1,730,375 | 10,457 | 186 | 209,611 | 769,745 |
| 1911. | 20,272 | 17,985 | 2,307 | 45,247 | ..... | 1,714,947 | 8,492 | ..... | 263,078 | 806,005 |
| 1912. | 68,500 | 30,894 | 610 | 27,724 | 453 | 2,186,930 | 9,852 | ..... | (f)295,751 | 876,773 |

| Year. | Gold. (b) | | | | Iron and steel bars, rods, etc. *Cwts.* | Lead. | | |
|---|---|---|---|---|---|---|---|---|
| | Ore. | Bullion. | Specie. | Total Value. | | Pig and matte. *Cwts.* | Argentiferous. *Cwts.* | Manufactures *Cwts.* |
| 1902.... | $1,214,208 | $20,736,800 | $41,954,939 | $63,905,947 | 3,182 | 365,830 | 638,359 | 17,429 |
| 1903.... | 80,591 | 29,691,889 | 53,634,629 | 83,407,109 | 5,753 | 633,816 | 553,308 | 28,783 |
| 1904.... | 46,894 | 27,073,767 | 49,284,833 | 76,405,494 | 4,952 | 1,626,292 | 790,435 | 20,552 |
| 1905.... | 49,507 | 25,788,574 | 27,523,288 | 53,361,369 | 4,821 | 1,302,428 | 753,008 | 34,629 |
| 1906.... | 20,296 | 24,113,950 | 47,937,681 | 72,071,927 | 11,560 | 1,031,605 | 781,426 | 20,358 |
| 1907.... | 17,513 | (c) 19,639,502 | 33,370,240 | 53,027,255 | 13,163 | 1,774,207 | ..... | 21,765 |
| 1908.... | 20,539 | (c) 18,924,716 | 50,794,544 | 69,739,799 | 13,015 | 2,132,199 | ..... | 20,161 |
| 1909.... | 270,131 | (c) 17,265,872 | 26,028,555 | 43,564,558 | 12,040 | 1,381,369 | ..... | 14,067 |
| 1910.... | 429,288 | (c) 11,970,906 | 10,598,747 | 22,998,940 | 17,106 | 1,800,856 | 845,856 | 13,350 |
| 1911.... | 327,101 | 10,456,322 | 47,831,267 | 58,614,700 | 117,131 | 1,755,650 | 430,073 | 14,610 |
| 1912.... | 340,474 | (c) 9,135,487 | 50,801,322 | 60,277,283 | 134,201 | 1,438,681 | 502,264 | 17,916 |

| Year. | Molybdenum Ore. *Cwts.* | Salt. *Cwts.* | Shale oil. | Silver. | | Tin. | | Spelter, Sheets, Concentrates, Dross, etc. *Cwts.* |
|---|---|---|---|---|---|---|---|---|
| | | | | Ore. (d) *Cwts.* | Bullion. *Kg.* | Ore. *Cwts.* | Block. *Cwts.* | |
| 1902..... | 160 | 238,192 | 27,896 | 1,439,374 | 189,703 | 10,291 | 63,424 | 4,461 |
| 1903..... | 783 | 155,613 | 14,483 | 1,653,794 | 202,730 | 26,900 | 82,473 | 60,206 |
| 1904..... | 1,100 | 141,553 | 8,202 | 2,235,385 | 227,972 | 40,339 | 99,476 | 309,422 |
| 1905..... | 1,381 | 174,987 | 11,818 | 581,651 | 208,134 | 55,153 | 108,963 | 3,006,372 |
| 1906..... | 1,867 | 198,851 | 7,203 | 1,010,707 | 174,457 | 51,793 | 130,120 | 2,592,018 |
| 1907..... | 2,025 | 189,194 | 5,686 | 907,790 | 294,679 | 65,005 | 131,407 | 5,393,784 |
| 1908..... | 2,116 | 240,348 | 19,173 | 1,137,746 | 326,250 | 49,409 | 121,979 | 6,235,024 |
| 1909..... | 1,055 | 230,486 | 3,983 | 1,914,479 | 90,989 | 8,559 | 111,262 | 6,994,745 |
| 1910..... | 1,972 | 184,892 | 9,307 | (f) 2,524,487 | 137,916 | 40,469 | 87,529 | 8,161,081 |
| 1911..... | 1,876 | 63,607 | 6,344 | (f) 2,795,970 | (e)218,388 | (f)55,721 | 82,935 | 8,648,818 |
| 1912..... | 2,873 | 123,779 | 290 | (f) 2,069,151 | 152,441 | (f)64,704 | 77,501 | 9,265,599 |

(a) From "Trade and Customs Returns," Commonwealth of Australia.—Note. Previous to 1900 each Colony reported its own exports separately. (b) Where gold or silver values are reported, £1 = $4.866. (c) Included with iron ore. (d) Includes lead ore. (e) Includes that contained in matte. (f) Includes concentrates. (g) Lead contents of matte, etc.

# AUSTRIA-HUNGARY

**In the following tables the mineral and metal productions of the two Kingdoms are reported separately, together with that of Bosnia and Herzegovina.**

MINERAL AND METALLURGICAL PRODUCTION OF AUSTRIA. (a)
(In metric tons.)

| Year. | Alum. | Alum and Pyritic Shale. | Antimony. | | Asphaltic Rock. | Bismuth Ore. | Coal. | |
|---|---|---|---|---|---|---|---|---|
| | | | Ore. | Metal. | | | Bituminous. | Lignitic. |
| 1898..... | 1,037 | 28,914 | 679 | 343 | 643 | *Nil* | 10,947,522 | 21,083,361 |
| 1899..... | 604 | 19,879 | 410 | 271 | 2,635 | 0.3 | 11,455,139 | 21,751,794 |
| 1900..... | 620 | 3,004 | 201 | 153 | 887 | 4.0 | 10,992,545 | 21,539,917 |
| 1901..... | 442 | 2,551 | 126 | 114 | 541 | 16.0 | 11,738,840 | 22,473,510 |
| 1902..... | 62 | 2,866 | 18 | 24 | 897 | 8.0 | 11,045,039 | 22,139,683 |
| 1903..... | *Nil* | 2,978 | 41 | 14 | 1,273 | 10.0 | 11,498,111 | 22,157,521 |
| 1904..... | *Nil* | 2,337 | 103 | 36 | 1,435 | 1.7 | 11,868,245 | 21,987,651 |
| 1905..... | *Nil* | 1,657 | 1,673 | 90 | 4,363 | 1.7 | 12,585,263 | 22,692,076 |
| 1906..... | *Nil* | 1,020 | 1,071 | *Nil* | 2,840 | 2.7 | 13,473,307 | 24,167,714 |
| 1907..... | *Nil* | *Nil* | 910 | 207 | 3,858 | *Nil* | 13,850,420 | 26,262,110 |
| 1908..... | *Nil* | *Nil* | 193 | 162 | 3,695 | *Nil* | 13,875,382 | 26,728,926 |
| 1909..... | *Nil* | *Nil* | 450 | *Nil* | 2,975 | *Nil* | 13,713,043 | 26,043,716 |
| 1910..... | *Nil* | *Nil* | 225 | *Nil* | 1,066 | *Nil* | 14,056,858 | 25,157,541 |
| 1911..... | *Nil* | *Nil* | 270 | ..... | 1,740 | ..... | 14,379,817 | 25,265,333 |

| Year. | Copper. | | | Copperas. | Gold. | | Graphite. | Iron. | |
|---|---|---|---|---|---|---|---|---|---|
| | Ore. | Metal. | Sulphate. | | Ore. | Bullion. | | Ore. | Pig & Cast |
| 1898..... | 6,791 | 1,041 | 209 | 360 | 448 | $47,515 | 33,062 | 1,733,649 | 837,767 |
| 1899..... | 6,731 | 1,123 | 235 | 475 | 387 | 50,306 | 31,819 | 1,725,143 | 872,353 |
| 1900..... | 5,825 | 881 | 234 | 474 | 227 | 47,183 | 33,663 | 1,894,458 | 879,132 |
| 1901..... | 7,406 | 776 | 256 | 472 | 143 | 31,234 | 29,992 | 1,963,246 | 884,844 |
| 1902..... | 8,455 | 914 | 248 | 271 | 74 | 4,652 | 29,527 | 1,742,498 | 991,827 |
| 1903..... | 12,688 | 961 | 310 | 298 | 2,148 | 5,316 | 29,590 | 1,715,984 | 970,832 |
| 1904..... | 10,701 | 889 | 808 | 414 | 12,653 | 47,183 | 28,620 | 1,719,219 | 988,364 |
| 1905..... | 10,677 | 870 | 540 | 116 | 35,937 | 133,218 | 34,416 | 1,913,782 | 1,119,614 |
| 1906..... | 20,255 | 877 | 578 | 154 | 33,033 | 83,401 | 38,117 | 2,253,662 | 1,222,230 |
| 1907..... | 10,400 | 592 | 579 | *Nil* | 30,711 | 92,471 | 49,425 | 2,540,118 | 1,383,524 |
| 1908..... | 8,381 | 683 | 556 | *Nil* | 28,907 | 98,504 | 44,425 | 2,632,407 | 1,466,897 |
| 1909..... | 11,826 | 985 | 591 | 70 | 29,709 | 98,295 | 40,710 | 2,490,277 | 1,465,051 |
| 1910..... | 8,005 | 1,468 | 715 | *Nil* | 31,744 | 118,895 | 33,131 | 2,627,513 | 1,504,786 |
| 1911..... | 10,974 | 1,760 | 767 | *Nil* | 29,647 | 134,840 | 41,599 | 2,765,815 | 1,596,148 |

| Year. | Lead. | | | Manganese. Ore. | Mineral Paint. | Petroleum. | Quicksilver. | | Salt. |
|---|---|---|---|---|---|---|---|---|---|
| | Ore. | Pig. | Litharge. | | | | Ore. | Metal. | |
| 1898..... | 14,363 | 10,340 | 1,520 | 6,132 | 3,213 | 323,142 | 88,519 | 491 | 341,959 |
| 1899..... | 12,820 | 9,736 | 1,526 | 5,411 | 2,055 | 309,590 | 92,323 | 536 | 342,059 |
| 1900..... | 14,314 | 10,650 | 1,288 | 8,804 | 2,828 | 347,213 | 94,747 | 510 | 330,277 |
| 1901..... | 16,688 | 10,161 | 1,317 | 7,796 | 1,701 | 404,662 | 97,360 | 525 | 333,238 |
| 1902..... | 19,055 | 11,264 | 1,023 | 5,646 | 1,486 | 520,845 | 90,040 | 511 | 311,806 |
| 1903..... | 22,196 | 12,162 | 923 | 6,179 | 1,691 | 672,508 | 83,321 | 523 | 359,015 |
| 1904..... | 22,514 | 12,645 | 783 | 10,189 | 1,829 | ..... | 88,279 | 536 | 369,877 |
| 1905..... | 23,339 | 12,968 | 865 | 13,788 | 798 | ..... | 86,856 | 520 | 343,375 |
| 1906..... | 19,683 | 14,846 | 1,059 | 13,402 | 943 | ..... | 91,494 | 526 | 378,912 |
| 1907..... | 22,792 | 13,598 | 863 | 16,756 | 1,091 | ..... | 89,370 | 527 | 395,053 |
| 1908..... | 21,513 | 12,669 | 1,010 | 16,656 | 475 | ..... | 90,145 | 572 | 388,133 |
| 1909..... | 20,550 | 12,941 | 840 | 18,045 | 620 | ..... | 92,337 | 585 | 359,801 |
| 1910..... | 22,841 | 15,476 | 602 | 15,694 | 698 | 1,766,018 | 100,899 | 603 | 345,629 |
| 1911..... | 23,845 | 18,097 | 318 | 15,954 | 2,902 | 1,487,842 | 111,018 | 704 | 342,732 |

| Year. | Silver. | | Sulphuric Acid. | Sulphur. Ore. | Tin. | | Tungsten Ore. | Uranium. | | Zinc. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ore. | Bullion. (*Kg.*) | | | Ore. | Block. | | Ore. | Salts. | Ore. | Spelter. |
| 1898. | 20,886 | 40,304 | 7,003 | 496 | 13 | 48 | 36 | 51 | 4.3 | 27,395 | 7,302 |
| 1899. | 21,554 | 39,564 | 7,814 | 555 | 54 | 41 | 50 | 49 | 7.6 | 37,100 | 7,192 |
| 1900. | 21,641 | 39,572 | 7,067 | 862 | 51 | 40 | 50 | 52 | 11.3 | 38,243 | 6,742 |
| 1901. | 21,363 | 40,205 | 7,073 | 4,911 | 42 | 49 | 45 | 48 | 13.0 | 36,072 | 7,558 |
| 1902. | 22,288 | 39,544 | 8,781 | 3,721 | 47 | 50 | 45 | 46 | 10.0 | 31,927 | 8,309 |
| 1903. | 21,958 | 39,812 | 9,105 | 4,475 | 57 | 34 | 49 | 45 | 6.0 | 29,544 | 8,949 |
| 1904. | 21,949 | 39,032 | 8,742 | 6,288 | 77 | 38 | 52 | 17 | 11.0 | 29,226 | 9,159 |
| 1905. | 21,047 | 38,453 | 1,007 | 8,407 | 52 | 53 | 55 | 16 | 13.9 | 29,983 | 9,326 |
| 1906. | 21,944 | 38,940 | 745 | 15,125 | 55 | 42 | 56 | 16 | 16.1 | 32,037 | 10,804 |
| 1907. | 22,636 | 38,742 | *Nil* | 24,099 | 53 | 47 | 44 | 11 | 11.2 | 31,970 | 11,208 |
| 1908. | 22,241 | 39,867 | *Nil* | 17,429 | 68 | 39 | 37 | 9 | 8.4 | 31,266 | 12,770 |
| 1909. | 21,102 | 39,002 | *Nil* | 12,725 | 36 | 52 | 39 | 13 | 10.2 | 33,955 | 11,688 |
| 1910. | 23,629 | 49,692 | ..... | 15,839 | 37 | 40 | 40 | 6.5 | 10.3 | 34,637 | 12,458 |
| 1911. | 24,143 | 50,244 | ..... | 15,805 | 944 | 15 | 45 | 5.8 | 6.8 | 32,166 | 15,766 |

(*a*) From the *Statistisches Jahrbuch des K. K. Ackerbau-Ministeriums.*

MINERAL AND METALLURGICAL PRODUCTION OF HUNGARY. (*a*)
(In metric tons or dollars; 1 crown = $0.203.)

| Year. | Antimony. | | Asphalt | Asphaltic Rock. | Bismuth. | Carbon Bisulphide. | Coal. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ore. | Regulus. | | | | | Bituminous. (*d*) | Lignite. (*d*) | Coke. | Briquets. |
| 1898... | 2,201 | 855 | 3,125 | ..... | 3.1 | 771 | 1,239,498 | 4,516,581 | (*c*) | 31,781 |
| 1899... | 1,965 | 940 | 3,060 | ..... | 3.0 | 1,120 | 1,238,855 | 4,292,584 | 10,336 | 31,137 |
| 1900... | 2,373 | 846 | 2,700 | ..... | 2.0 | 1,250 | 1,447,047 | 5,128,277 | 12,973 | 69,353 |
| 1901... | (*b*) 323 | 706 | 2,878 | 25,161 | 1.6 | 2,087 | 1,365,270 | 5,179,829 | 10,975 | 40,182 |
| 1902... | (*b*) 748 | 683 | 2,774 | 24,873 | 0.9 | 2,320 | 1,162,785 | 5,132,053 | 8,204 | 88,069 |
| 1903... | (*b*) 205 | 732 | 2,422 | 21,552 | 1.5 | 2,357 | 1,233,410 | 5,271,781 | 9,442 | 101,197 |
| 1904... | 1,080 | 1,007 | 2,221 | 17,660 | 0.9 | 2,512 | 1,155,320 | 5,519,349 | 5,103 | 103,481 |
| 1905... | 949 | 756 | 173 | 19,372 | 1.4 | 2,760 | 919,193 | 6,015,452 | 69,303 | 144,697 |
| 1906... | 1,807 | 954 | 4,111 | 34,664 | 2.0 | 2,756 | 1,103,529 | 6,229,712 | 79,930 | 151,657 |
| 1907... | 2,035 | 841 | 3,920 | 33,096 | 0.4 | 2,950 | 1,038,819 | 6,408,322 | 97,447 | 154,783 |
| 1908... | 1,316 | 670 | 4,818 | 72,972 | (*c*) | 2,966 | 982,017 | 7,034,499 | 141,954 | 109,178 |
| 1909... | 1,971 | 695 | 5,054 | ..... | ..... | 3,086 | 1,397,424 | 7,658,719 | 157,415 | 117,594 |
| 1910... | 1,939 | 782 | 4,994 | ..... | ..... | 3,245 | 1,302,103 | 7,734,166 | 156,048 | 108,873 |
| 1911... | 2,616 | 892 | 3,861 | ..... | ..... | 3,488 | 1,290,182 | 8,154,560 | 145,104 | 118,412 |

| Year. | Copper. | Copperas. | Gold. | Iron. | | | Lead. | | Litharge. | Manganese Ore. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ore. (*d*) | Pig. | Cast. | Ore. | Pig. | | |
| 1898... | 153 | 745 | $1,839,474 | 1,666,837 | 448,621 | 20,784 | 771 | 2,305 | 188 | 8,087 |
| 1899... | 165 | 771 | 2,039,504 | 1,587,600 | 451,637 | 19,631 | 526 | 2,166 | 213 | 5,073 |
| 1900... | 181 | 700 | 2,173,079 | 1,666,363 | 432,817 | 22,738 | 612 | 2,030 | 201 | 5,746 |
| 1901... | 162 | 805 | 2,189,692 | 1,557,300 | 430,686 | 20,640 | (*b*) 10 | 2,029 | 238 | 4,591 |
| 1902... | 89 | 909 | 2,260,135 | 1,562,238 | 416,835 | 18,569 | (*b*) 20 | 2,244 | 219 | 7,237 |
| 1903... | 45 | 982 | 2,243,521 | 1,439,132 | 396,674 | 18,875 | (*d*)3,698 | 2,057 | 257 | 5,311 |
| 1904... | 63 | 1,277 | 2,437,988 | 1,524,036 | 370,297 | 17,203 | (*d*)3,922 | 2,104 | 710 | 11,527 |
| 1905... | 73 | 920 | 2,439,451 | 1,661,358 | 403,719 | 17,563 | 686 | 2,146 | 209 | 5,708 |
| 1906... | 69 | 1,306 | 2,487,156 | 1,698,291 | 402,527 | 17,164 | 564 | 1,925 | 698 | 7,176 |
| 1907... | 85 | 1,212 | 2,330,292 | (*e*)622,518 | 423,134 | 17,103 | 8 | 1,468 | 441 | 8,198 |
| 1908... | 166 | 1,372 | 2,189,801 | (*e*)727,019 | 505,559 | 17,415 | 3 | 1,544 | 190 | 10,601 |
| 1909... | 265 | 1,414 | 1,813,024 | 1,965,487 | 514,853 | 15,577 | | 1,590 | 625 | 11,921 |
| 1910... | 214 | 1,313 | 2,022,032 | 1,905,749 | 487,421 | 14,635 | 91 | 2,077 | 570 | 13,270 |
| 1911... | 208 | 849 | 2,125,241 | 1,950,231 | 502,460 | 15,990 | 239 | 1,583 | 391 | 14,755 |

| Year. | Mineral Paints. | Petroleum. | Pyrites. | Quicksilver. *Kg.* | Salt. | Silver. *Kg.* | Sulphur. | Sulphuric Acid. | Zinc. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Ore.(*b*) | Spelter. |
| 1899... | 394 | 2,125 | 79,519 | 27,000 | 200,525 | 20,991 | 116 | 1,463 | 1,197 | ..... |
| 1900... | 370 | 2,199 | 87,000 | 31,800 | 212,957 | 20,202 | 123 | 1,371 | 326 | ..... |
| 1901... | 305 | 3,296 | 93,907 | 33,003 | 215,581 | 23,636 | 137 | 1,464 | 693 | 14 |
| 1902... | 283 | 4,347 | 106,490 | 44,600 | 217,079 | 23,020 | 105 | 1,193 | 364 | ..... |
| 1903... | 263 | 3,010 | 96,619 | 43,700 | 214,536 | 19,281 | 135 | 1,543 | 46 | 26 |
| 1904... | 273 | 2,134 | 97,148 | 45,169 | 230,943 | 16,352 | 143 | 1,329 | 203 | ..... |
| 1905... | 196 | 471 | 106,848 | 36,000 | 238,642 | 15,946 | 135 | 1,410 | 173 | ..... |
| 1906... | 221 | 2,692 | 112,,623 | 50,100 | 245,402 | 13,642 | 133 | 1,457 | 243 | 146 |
| 1907... | 259 | 2,404 | 99,503 | 40,400 | (*c*) | 12,695 | (*c*) | 1,232 | (*c*) | (*c*) |
| 1908... | 294 | 2,427 | 95,824 | 78,000 | (*c*) | 12,612 | 144 | 1,444 | 135 | (*c*) |
| 1909. . | 63 | 2,590 | 98,971 | 71,500 | 231,182 | 10,932 | 131 | 1,307 | (0) | ..... |
| 1910. . | 55 | 2,501 | 92,464 | 90,000 | 230,315 | 12,547 | 128 | 1,334 | 280 | ..... |
| 1911... | 69 | 2,191 | 96,755 | 79,700 | 239,006 | 10,806 | 51 | 938 | 106 | ..... |

(*a*) From the *Annuaire Statistique Hongrois.* (*b*) Includes only that part of the crude output that was not smelted into a refined product. (*c*) Not reported. (*d*) Total production. (*e*) Exported.

## MINERAL AND METALLURGICAL PRODUCTION OF BOSNIA AND HERZEGOVINA. (*a*)

(In metric tons.)

| Year. | Chrome Ore. | Copper | | Iron. | | Lignite. | Manganese Ore. | Pyrites. | Quicksilver. | Salt. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Ore. | Metal. | Ore. | Pig. | | | | | |
| 1900... | 100 | 3,008 | 141 | 133,454 | 38,960 | 394,516 | 7,939 | 1,710 | 6.7 | 15,791 |
| 1901... | 505 | 3,696 | 199 | 122,569 | 39,296 | 445,007 | 6,346 | 4,570 | 9.3 | 16,865 |
| 1902... | 270 | 3,657 | 166 | 133,348 | 43,992 | 424,753 | 5,760 | 5,170 | 7.2 | 17,348 |
| 1903... | 147 | 1,073 | 191 | 114,059 | 39,833 | 467,962 | 4,538 | 6,589 | 8.1 | 18,459 |
| 1904... | 279 | 640 | 115 | 127,297 | 47,678 | 483,617 | 1,114 | 10,412 | 8.1 | 18,021 |
| 1905... | 186 | 670 | 39 | 122,540 | 43,074 | 540,237 | 4,129 | 19,045 | 10.0 | (*b*) |
| 1906... | 320 | 765 | 25 | 136,513 | 45,660 | 594,172 | 7,651 | 11,347 | 5.1 | 22,671 |
| 1907... | 310 | 245 | *Nil.* | 150,684 | 48,946 | 621,179 | 7,000 | 7,229 | 1.2 | 21,148 |
| 1908 (*c*) | 315 | (*b*) | *Nil.* | 150,075 | 48,900 | 630,500 | 6,000 | (*b*) | *Nil.* | 22,100 |
| 1909 (*c*) | 310 | (*b*) | *Nil.* | 145,200 | 48,850 | 675,400 | 5,000 | (*b*) | *Nil.* | 22,500 |
| 1910... | 320 | (*b*) | *Nil.* | 132,720 | 48,841 | 706,659 | 4,000 | 571 | *Nil.* | 23,579 |
| 1911... | 250 | (*b*) | *Nil.* | 140,283 | 44,354 | 769,763 | 3,600 | 3,118 | *Nil.* | 22,591 |
| 1912... | 200 | ..... | *Nil.* | 150,420 | 53,270 | 852,920 | 4,650 | 6,216 | *Nil.* | 23,124 |

(*a*) From *Oestr. Zeit. f. B.-u. H.* (*b*) Not reported. (*c*) Estimated.

## MINERAL EXPORTS OF AUSTRIA-HUNGARY. (*a*)

(In metric tons or dollars; 5 crowns = $1.)

| Year. | Alum. | Aluminum Sulphate and Chloride. | Antimony. | | Arsenic, Metallic, Oxide, Orpiment and Realgar. | Asbestos. | | Asphalt. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Ore. | Regulus. | | Crude. | Manufactured. | Rock and Earth. | Mastic and Bitumen. |
| 1899.... | 54 | 233 | 562 | 240 | 47 | 71 | 60 | 1,143 | 2,619 |
| 1900.... | 44 | 164 | 247 | 276 | 65 | 47 | 168 | 1,218 | 2,177 |
| 1901.... | 55 | 211 | 179 | 385 | 80 | 36 | 165 | 198 | 1,909 |
| 1902.... | 102 | 135 | 174 | 290 | 89 | 65 | 275 | 520 | 301 |
| 1903.... | 77 | 14 | 128 | 249 | 63 | 89 | 495 | 921 | 483 |
| 1904.... | 38 | 2 | 200 | 673 | 72 | 290 | 1,582 | 403 | 728 |
| 1905.... | 68 | 34 | 178 | 774 | 42 | 330 | 1,397 | 1,060 | 457 |
| 1906 (*f*). | 68 | 80 | 314 | 912 | 66 | 376 | 1,708 | 2,824 | 799 |
| 1907.... | 75 | 81 | 92 | 698 | 59 | 351 | 630 | 3,787 | 771 |
| 1908.... | 147 | 92 | 161 | 527 | 51 | 442 | 450 | 1,312 | 1,030 |
| 1909.... | 65 | 57 | 97 | 185 | 117 | 264 | 561 | 1,800 | 758 |
| 1910.... | 346 | 85 | 54 | 416 | 9 | 262 | 604 | 1,545 | 954 |
| 1911.... | 157 | 16 | 77 | 267 | 13 | 141 | 992 | 1,845 | 1,218 |
| 1912.... | 311 | 7 | 54 | 689 | 2 | 530 | 779 | 1,357 | 1,920 |

| Year. | Barium. | | Chloride of Lime. | Cement. | Chrome Ore. | Kaolin and Feldspar. | Coal. | | Coke. |
|---|---|---|---|---|---|---|---|---|---|
| | Sulphate (b) | Chloride. | | | | | Bituminous. | Lignitic. | |
| 1899 | 65 | ..... | 203 | 38,193 | 53 | 78,537 | 879,337 | 8,662,788 | 252,971 |
| 1900 | 23 | ..... | 192 | 46,761 | 22 | 103,178 | 815,097 | 7,864,410 | 262,793 |
| 1901 | 55 | 4,098 | 738 | 44,723 | 62 | 97,037 | 748,802 | 8,076,575 | 303,651 |
| 1902 | 64 | 4,552 | 426 | 39,920 | 51 | 100,546 | 691,680 | 7,888,218 | 234,911 |
| 1903 | 52 | 5,091 | 674 | 40,239 | 100 | 110,181 | 754,957 | 8,027,347 | 280,395 |
| 1904 | 74 | 4,233 | 254 | 43,110 | 36 | 127,984 | 815,570 | 7,588,555 | 353,695 |
| 1905 | 26 | 4,626 | 978 | 52,830 | 46 | 137,125 | 903,156 | 8,035,718 | 287,790 |
| 1906(f) | 2,395 | 4,503 | 271 | 64,883 | 102 | 133,326 | 750,420 | 7,150,339 | 246,914 |
| 1907 | 3,119 | 5,220 | 308 | 81,407 | 161 | 157,894 | 849,792 | 8,876,408 | 323,243 |
| 1908 | 2,987 | 2,974 | 519 | 65,597 | 144 | 154,146 | 762,867 | 8,600,683 | 183,279 |
| 1909 | 2,585 | 3,737 | 462 | 63,463 | 174 | 150,878 | 633,253 | 8,241,723 | 198,313 |
| 1910 | 13 | 4,344 | 1,213 | 98,888 | 140 | 164,859 | 615,082 | 7,492,447 | 230,735 |
| 1911 | 12 | 3,741 | 1,175 | 168,321 | 70 | 174,493 | 609,737 | 7,063,981 | 299,915 |
| 1912 | 2,690 | 3,658 | 1,518 | 149,860 | 95 | 187,358 | 655,106 | 7,442,392 | 349,384 |

| Year. | Fluorspar. | Copper. | | | Copper Sulphate. | Copperas. | Cryolite. |
|---|---|---|---|---|---|---|---|
| | | Ore. | Crude and Old. | Bars, Sheets Plates, etc. | | | |
| 1899 | 309 | 74 | 534 | 298 | 67 | 808 | 101 |
| 1900 | 45 | 801 | 471 | 200 | 57 | 748 | 237 |
| 1901 | 6 | 1,042 | 435 | 334 | 23 | 548 | 231 |
| 1902 | 42 | 1,018 | 436 | 381 | 44 | 857 | 363 |
| 1903 | 12 | 1,308 | 1,226 | 451 | 45 | 898 | 521 |
| 1904 | 36 | 574 | 747 | 577 | 50 | 1,170 | 574 |
| 1905 | 5 | 2,328 | 1,253 | 746 | 49 | 836 | 638 |
| 1906 | *Nil.* | 341 | 1,007 | 816 | 99 | 861 | *Nil.* |
| 1907(f) | *Nil.* | 489 | 624 | 870 | 11 | 1,580 | *Nil.* |
| 1908 | 7 | 206 | 1,126 | 791 | 63 | 2,199 | *Nil.* |
| 1909 | 12 | 136 | 1,250 | 541 | 40 | 1,877 | *Nil.* |
| 1910 | 4 | 101 | 977 | 700 | 83 | 2,273 | 42 |
| 1911 | 0.2 | 126 | 1,309 | 1,109 | 14 | 2,124 | 122 |
| 1912 | 13 | 516 | 1,332 | 1,642 | 119 | ..... | 46 |

| Year. | Gold. | | | Graphite. | Gypsum. | | Hydrochloric Acid. |
|---|---|---|---|---|---|---|---|
| | Ore. | Bullion. (e) | Specie. (e) | | Crude. | Calcined. | |
| 1899 | 67 | $17,864 | $12,711,454 | 19,451 | 634 | 1,539 | 1,495 |
| 1900 | 1 | 120,988 | 11,582,571 | 18,995 | 502 | 1,723 | 1,659 |
| 1901 | 0 | 42,427 | 6,880,888 | 14,900 | 461 | 1,206 | 1,632 |
| 1902 | ..... | 22,939 | 13,485,087 | 16,771 | 550 | 1,041 | 791 |
| 1903 | 3 | 10,150 | 11,052,944 | 17,302 | 342 | 1,510 | 3,530 |
| 1904 | 64 | 5,278 | 9,649,605 | 17,430 | 392 | 1,510 | 3,722 |
| 1905 | 1,059 | 9,338 | 10,995,089 | 18,535 | 363 | 1,652 | 4,085 |
| 1906 | 936 | 88,264 | 8,015,967 | 16,871 | 1,970 | 686 | 2,942 |
| 1907 (f) | 996 | 1,234,291 | 13,061,517 | 21,704 | 3,841 | 801 | 3,708 |
| 1908 | 613 | 70,005 | 11,978,828 | 16,535 | 7,241 | 807 | 3,720 |
| 1909 | 548 | 3,426,539 | 19,470,382 | 18,484 | 3,675 | 809 | 3,263 |
| 1910 | (h) | 1,750,600 | 10,891,800 | 21,191 | 5,110 | 590 | 4,856 |
| 1911 | (h) | 6,909,408 | 15,220,358 | 21,204 | 3,689 | 914 | 5,834 |
| 1912 | 573 | 10,952,642 | 21,008,500 | 25,246 | 4,113 | 1,174 | 8,461 |

(h) Values in gold $40,200 and $38,760.

| Year. | Iron. | | | | Lime. | Magnesium Chloride and Glauber Salts. | Magnesite (Calcined). |
|---|---|---|---|---|---|---|---|
| | Ore. | Pig and Old. | Manufactures. | Iron and Steel Bars, Sheets, Wire, etc. | | | |
| 1899 ... | 326,951 | 27,738 | 30,822 | 50,197 | 85,570 | 5,721 | (c) |
| 1900 ... | 263,421 | 53,426 | 40,344 | 65,019 | 86,273 | 7,321 | (c) |
| 1901 ... | 229,624 | 26,304 | 46,508 | 28,841 | 82,399 | 7,960 | 40,236 |
| 1902 ... | 241,806 | 42,592 | 30,137 | 45,517 | 81,634 | 5,333 | 53,467 |
| 1903 ... | 252,520 | 60,237 | 40,807 | 63,031 | 95,644 | 2,360 | 69,058 |
| 1904 ... | 295,017 | 66,442 | 60,252 | 64,698 | 101,753 | 2,151 | 53,781 |
| 1905 ... | 373,077 | 63,780 | 63,828 | 69,672 | 94,751 | 1,272 | 92,359 |
| 1906(f) | 234,924 | 43,694 | 73,575 | 50,247 | 87,468 | 4,094 | 87,765 |
| 1907 ... | 220,767 | 37,581 | 56,472 | 69,669 | 89,305 | 6,905 | 113,695 |
| 1908 ... | 220,357 | 17,494 | 32,110 | 29,227 | 62,938 | 2,622 | 87,049 |
| 1909 ... | 178,464 | 22,627 | 25,455 | 40,837 | 77,586 | 5,446 | 125,666 |
| 1910 ... | 144,827 | 96,114 | 73,473 | 100,541 | 391,989 | 6,332 | 182,911 |
| 1911 ... | 114,166 | 87,975 | 60,918 | 75,630 | 511,996 | 2,715 | 147,481 |
| 1912 ... | 111,436 | 50,328 | 48,147 | 49,907 | 583,812 | 2,212 | 171,196 |

| Year. | Lead. | | | | | | Manganese ore. | Millstones. | Mineral Paints. | Nickle and Cobalt ores. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ore. | Dross. | Litharge | Metal and Alloys. | Red and Yellow. | White. | | | | |
| 1899.... | 2,502 | 99 | 188 | 258 | 45 | 41 | 1,127 | 1,904 | 2,061 | 75 |
| 1900.... | 2,628 | 66 | 242 | 393 | 34 | 34 | 463 | 1,871 | 1,906 | 114 |
| 1901.... | 4,143 | 112 | 179 | 68 | 32 | 23 | 398 | 1,971 | 1,947 | 120 |
| 1902.... | 5,478 | 154 | 124 | 109 | 25 | 37 | 411 | 1,886 | 2,136 | 34 |
| 1903.... | 8,961 | 147 | 145 | 152 | 19 | 25 | 724 | 2,311 | 1,873 | 12 |
| 1904.... | 7,575 | 144 | 167 | 464 | 54 | 52 | 1,234 | 2,276 | 1,840 | 26 |
| 1905.... | 7,944 | 342 | 141 | 957 | 60 | 39 | 995 | 2,232 | 2,091 | 16 |
| 1906(f) | 4,891 | 223 | 302 | 602 | 16 | 52 | 4,170 | 1,763 | 1,367 | 42 |
| 1907.... | 8,360 | 420 | 255 | 197 | 9 | 54 | 5,273 | 2,422 | 1,697 | 29 |
| 1908.... | 7,107 | 488 | 312 | 199 | 22 | 50 | 2,109 | 3,293 | 2,292 | Nil. |
| 1909.... | 5,711 | 294 | 343 | 306 | 125 | 80 | 787 | 3,849 | 2,577 | Nil. |
| 1910.... | 6,163 | 322 | 160 | 418 | 44 | 510 | 285 | 3,970 | 3,542 | 13 |
| 1911.... | 5,493 | 154 | 768 | 670 | 24 | 35 | 588 | 3,513 | 3,426 | 1 |
| 1912.... | 8,618 | ..... | 28 | 548 | 19 | 82 | 534 | 3,530 | 4,272 | 0.3 |

| Year. | Nitric Acid. | Ozokerite. | Peat and Peat Coke. | Petroleum. (d) | Benzine. | Paraffin. | Potash. | Potassium Chloride. | Pyrites. | Sulphur. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1899.... | 420 | 5,441 | 4,010 | 11,756 | 20,646 | 10 | 10,113 | 974 | 5,201 | 885 |
| 1900.... | 519 | 5,162 | 5,607 | 33,032 | 18,361 | 26 | 7,792 | 879 | 17,162 | 1,285 |
| 1901.... | 632 | 2,717 | 4,558 | 19,804 | 17,021 | 14 | 4,234 | 909 | 16,491 | 1,225 |
| 1902.... | 769 | 2,285 | 4,927 | 40,683 | 13,884 | 24 | 3,229 | 772 | 9,547 | 1,136 |
| 1903.... | 908 | 2,258 | 3,638 | 74,454 | 14,000 | 1,153 | 3,409 | 802 | 10,857 | 1,123 |
| 1904.... | 858 | 2,093 | 3,980 | 122,419 | 13,706 | 5,992 | 4,604 | 445 | 9,891 | 988 |
| 1905.... | 1,377 | 1,614 | 3,746 | 200,736 | 8,187 | 8,996 | 5,511 | 1,048 | 9,168 | 859 |
| 1906(f) | 1,303 | 2,034 | 2,517 | 198,325 | 13,472 | 9,996 | 3,814 | 1,005 | 7,208 | 760 |
| 1907.... | 754 | 1,813 | 4,001 | 212,527 | 12,638 | 14,758 | 5,864 | 1,280 | 5,646 | 784 |
| 1908.... | 882 | 1,648 | 4,416 | 351,262 | 25,599 | 28,808 | 4,697 | 776 | 6,286 | 998 |
| 1909.... | 745 | 2,321 | 3,395 | 470,085 | 32,532 | 38,043 | 5,667 | 793 | 4,975 | 1,295 |
| 1910.... | 1,121 | 2,585 | 1,963 | 271,467 | 39,452 | 44,432 | 5,271 | 957 | 4,565 | 658 |
| 1911.... | 1,047 | 1,859 | 2,869 | 220,499 | 41,923 | 38,058 | 4,801 | 943 | 1,190 | 534 |
| 1912.... | 1,251 | 2,525 | 1,421 | 338,271 | 68,686 | 51,694 | 4,456 | 855 | 5,081 | 1,048 |

| Year. | Sulphuric Acid. | Tin. | | | Whetstones. | Zinc. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Ingot and Alloys. | Bars, Plates, Sheets, etc. | Dross. | | Ore. | Metallic and Alloys. | Sheets, etc. | White. | Dross. |
| 1899... | 12,422 | 167 | 77 | 273 | 2,215 | 20,461 | 1,614 | 1,313 | 1,096 | 73 |
| 1900... | 12,693 | 153 | 102 | 208 | 2,270 | 20,379 | 1,088 | 502 | 1,719 | 149 |
| 1901... | 10,373 | 162 | 109 | 257 | 2,359 | 23,150 | 1,374 | 813 | 2,720 | 167 |
| 1902... | 9,451 | 193 | 128 | 188 | 2,852 | 24,519 | 2,002 | 1,127 | 3,113 | 237 |
| 1903... | 8,369 | 292 | 111 | 158 | 2,569 | 15,108 | 4,420 | 729 | 3,446 | 267 |
| 1904... | 9,101 | 126 | 102 | 123 | 2,159 | 17,314 | 4,606 | 532 | 3,666 | 158 |
| 1905... | 12,823 | 197 | 94 | 78 | 2,355 | 19,602 | 5,023 | 498 | 3,861 | 113 |
| 1906(*f*) | 10,493 | 221 | 62 | 83 | 1,541 | 15,933 | 4,578 | 323 | 3,504 | 4,285 |
| 1907... | 15,190 | 333 | 84 | 160 | 1,900 | 19,516 | 4,608 | 585 | 4,873 | 4,873 |
| 1908... | 13,581 | 257 | 49 | 172 | 2,009 | 19,233 | 6,604 | 880 | 4,131 | 4,131 |
| 1909... | 11,232 | 558 | 82 | 59 | 1,677 | 19,970 | 7,031 | 867 | 5,078 | 5,078 |
| 1910... | 12,016 | 509 | 58 | 70 | 2,411 | 22,397 | 8,720 | 303 | 4,968 | (*g*) |
| 1911... | 12,111 | 759 | 77 | 59 | 1,769 | 16,744 | 710 | 411 | 4,639 | (*g*) |
| 1912... | 16,216 | (*h*)1,043 | 42 | ..... | 1,563 | 14,539 | (*h*)10,244 | 2,483 | [58,909 | ..... |

(*a*) From *Statistik des Auswaertigen Handels des Oesterreichisch-Ungarischen Zollgebiets.* (*b*) Includes artificial barium sulphate. (*c*) Previous to 1901, magnesite was included with other minerals not elsewhere specified. (*d*) From 1895 to 1898 inclusive, includes crude and refined petroleum; from 1899 to 1905 inclusive, lubricating oil is also included. (*e*) Where gold or silver values are reported 1 crown = $0.203. (*f*) Last 10 months only. (*g*) Not reported. (*h*) Includes dross.

MINERAL IMPORTS OF AUSTRIA-HUNGARY. (*a*)
(In metric tons or dollars; 5 Crowns = $1.)

| Year. | Alum. | Aluminum and Alloys. | Aluminum Sulphate and Chloride. | Antimony. | | Arsenic. (*b*) | Asbestos. | |
|---|---|---|---|---|---|---|---|---|
| | | | | Ore. | Regulus—*Kg.* | | Crude. (*c*) | Manufactures. |
| 1899..... | 332 | 121 | 1,299 | 10 | 30,400 | 284 | 866 | 1,347 |
| 1900..... | 430 | 154 | 1,435 | 46 | 23,000 | 320 | 1,085 | 1,238 |
| 1901..... | 413 | 153 | 1,882 | 27 | 1,500 | 351 | 1,678 | 1,032 |
| 1902..... | 537 | 151 | 2,161 | 40 | 18,200 | 351 | 2,038 | 798 |
| 1903..... | 508 | 150 | 2,670 | 42 | 87,200 | 371 | 3,395 | 1,221 |
| 1904..... | 602 | 231 | 2,346 | 64 | 21,000 | 384 | 2,517 | 1,240 |
| 1905..... | 774 | 477 | 2,775 | 42 | 24,700 | 342 | 5,962 | 208 |
| 1906(*f*) .. | 513 | 216 | 2,840 | 79 | 38,900 | 83 | 7,025 | 111 |
| 1907..... | 545 | 255 | 3,200 | 231 | 89,900 | 325 | 5,729 | 180 |
| 1908..... | 567 | 323 | 2,606 | 304 | 128,200 | 349 | 9,484 | 139 |
| 1909..... | 359 | 418 | 1,831 | 95 | 80,100 | 370 | 12,003 | 200 |
| 1910..... | 589 | 303 | 1,474 | 96 | 121,800 | 416 | 11,602 | 250 |
| 1911..... | 375 | 516 | 1,317 | 98 | 124,600 | 377 | 16,071 | 276 |
| 1912..... | 253 | 1,224 | 1,396 | 91 | 49,000 | 24 | 24,615 | 338 |

| Year. | Asphalt. | | Barytes. | Borax. | | Cement. | Chloride of Lime. | Chrome Ore. |
|---|---|---|---|---|---|---|---|---|
| | Crude Rock | Mastic and Bitumen. | | Crude and Boric Acid. | Refined. | | | |
| 1899..... | 7,301 | 1,546 | 5,443 | 2,212 | 130 | 21,410 | 3,749 | 1,874 |
| 1900..... | 8,301 | 1,564 | 5,945 | 3,056 | 93 | 25,747 | 3,326 | 2,823 |
| 1901..... | 5,702 | 1,106 | 6,336 | 1,687 | 233 | 23,559 | 3,326 | 860 |
| 1902..... | 5,732 | 1,273 | 6,266 | 2,168 | 174 | 18,658 | 2,596 | 2,668 |
| 1903..... | 5,871 | 1,272 | 7,057 | 2,192 | 150 | 23,256 | 2,791 | 2,121 |
| 1904..... | 8,211 | 1,064 | 6,238 | 2,752 | 142 | 20,259 | 3,407 | 1,209 |
| 1905..... | 8,553 | 1,139 | 6,187 | 3,099 | 205 | 21,950 | 1,847 | 2,305 |
| 1906(*f*)..... | 13,381 | 895 | 9,654 | 3,519 | 126 | 21,833 | 2,491 | 1,612 |
| 1907..... | 9,394 | 1,637 | 11,669 | 3,763 | 138 | 23,697 | 2,534 | 2,795 |
| 1908..... | 11,678 | 1,305 | 11,241 | 4,105 | 158 | 39,135 | 2,395 | 1,837 |
| 1909..... | 9,113 | 1,309 | 13,940 | 3,240 | 139 | 53,262 | 3,105 | 2,223 |
| 1910..... | 15,897 | 1,101 | 21,486 | 5,284 | 166 | 81,251 | 1,885 | 1,271 |
| 1911..... | 18,394 | 1,990 | 20,501 | 4,407 | 193 | 80,613 | 3,131 | 2,217 |
| 1912..... | 25,111 | 4,295 | 21,375 | 4,286 | 482 | 83,630 | 2,802 | 4,329 |

| Year. | Kaolin and Feldspar. | Coal. | | Coke. | Copper. | | | Copper Sulphate. |
|---|---|---|---|---|---|---|---|---|
| | | Bituminous. | Lignitic. | | Ore. | Bullion and Scrap. | Bars, Sheets, Wire, etc. | |
| 1899..... | 8,152 | 5,296,700 | 20,879 | 564,005 | *Nil* | 16,185 | 156 | 2,345 |
| 1900..... | 6,847 | 6,242,939 | 67,740 | 620,776 | 16 | 18,970 | 121 | 3,516 |
| 1901..... | 7,687 | 5,827,332 | 22,253 | 612,209 | 112 | 17,504 | 83 | 2,822 |
| 1902..... | 9,085 | 5,766,377 | 29,601 | 547,406 | 100 | 18,498 | 149 | 2,839 |
| 1903..... | 9,940 | 5,907,660 | 30,007 | 519,281 | 209 | 18,701 | 89 | 3,526 |
| 1904..... | 10,854 | 6,190,030 | 30,001 | 548,272 | 1,107 | 22,532 | 89 | 4,508 |
| 1905..... | 13,656 | 6,418,042 | 36,000 | 554,147 | 1,397 | 22,652 | 73 | 3,791 |
| 1906 (*f*)... | 13,219 | 5,942,897 | 17,464 | 406,088 | 267 | 20,943 | 481 | 1,597 |
| 1907..... | 17,961 | 9,692,645 | 23,699 | 677,750 | 44 | 26,181 | 818 | 3,981 |
| 1908..... | 17,417 | 9,995,415 | 30,433 | 851,099 | 121 | 33,270 | 1,140 | 8,402 |
| 1909..... | 16,185 | 10,482,264 | 38,679 | 701,281 | 13 | 30,606 | 568 | 4,129 |
| 1910..... | 17,817 | 9,864,462 | 37,867 | 670,089 | 49 | 32,217 | 926 | 3,445 |
| 1911..... | 22,828 | 10,873,799 | 34,381 | 702,707 | 716 | 37,251 | 538 | 6,598 |
| 1912..... | 24,628 | 11,848,535 | 34,871 | (*h*)915,547 | 765 | 45,460 | 850 | 16,111 |

| Year. | Copperas. | Cryolite. | Fluorspar. | Gold. (*d*) | | Graphite. | Gypsum. | | Hydrochloric Acid. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Bullion. | Coin. | | Crude. | Burned. | |
| 1899..... | 409 | 343 | 4,959 | $432,187 | $7,662,641 | 815 | 1,336 | 13,441 | 350 |
| 1900..... | 343 | 342 | 5,649 | 1,111,831 | 7,230,251 | 302 | 1,348 | 15,462 | 577 |
| 1901..... | 269 | 428 | 5,774 | 13,865,103 | 20,353,592 | 318 | 1,405 | 15,830 | 576 |
| 1902..... | 274 | 447 | 5,902 | 14,509,019 | 15,695,960 | 221 | 1,588 | 16,430 | 588 |
| 1903..... | 155 | 521 | 5,445 | 9,825,200 | 9,817,283 | 405 | 1,969 | 18,655 | 603 |
| 1904..... | 238 | 313 | 7,061 | 12,703,740 | 8,586,394 | 423 | 2,384 | 19,387 | 459 |
| 1905..... | 169 | 220 | 7,601 | 1,047,792 | 9,204,968 | 735 | 1,553 | 21,286 | 656 |
| 1906(*f*) .. | 186 | 217 | 7.795 | 989,604 | 5,229,591 | 854 | 4,104 | 10,308 | 476 |
| 1907..... | 187 | 613 | 8,779 | 1,106,002 | 5,755,918 | 934 | 5,813 | 11,981 | 629 |
| 1908..... | 74 | 564 | 7,359 | 7,303,982 | 7,969,538 | 755 | 4,993 | 10,842 | 924 |
| 1909..... | 56 | 556 | 8,106 | 36,744,037 | 8,631,453 | 660 | 4,907 | 10,410 | 898 |
| 1910..... | 89 | 703 | 8,292 | 1,399,400 | 4,485,600 | 1,124 | 5,733 | 20,390 | 635 |
| 1911..... | 66 | 944 | 9,446 | 3,163,554 | 1,902,798 | 1,173 | 6,616 | 16,489 | 612 |
| 1912..... | ..... | 1053 | 6,396 | 667,350 | 1,516,911 | 1,834 | 10,585 | 24,944 | 1,115 |

| Year. | Iron. | | | | Lead. | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ore. | Pig and Old. | Manufactures. | Iron and Steel Bars Sheets Wire etc. | Ore. | Pig, Alloys, Crude. | Litharge. | Red and Yellow. | White. |
| 1899..... | 212,412 | 126,371 | $4,395,356 | 12,340 | 465 | 8,836 | 224 | 466 | 80 |
| 1900..... | 233,156 | 95,530 | 4,533,599 | 10,313 | 501 | 7,916 | 141 | 354 | 106 |
| 1901..... | 218,476 | 90,287 | 4,443,670 | 10,902 | 1,270 | 10,722 | 189 | 433 | 135 |
| 1902..... | 197,525 | 43,314 | 4,304,818 | 11,584 | 1,879 | 8,706 | 149 | 428 | 221 |
| 1903..... | 217,979 | 47,354 | 4,508,224 | 11,025 | 1,355 | 9,190 | 141 | 423 | 173 |
| 1904..... | 182,515 | 35,091 | 4,976,342 | 9,402 | 1,436 | 7,917 | 146 | 372 | 138 |
| 1905..... | 228,149 | 49,383 | 5,722,976 | 33,256 | 247 | 7,282 | 101 | 349 | 88 |
| 1906(*f*)..... | 232,558 | 57,341 | 6,153,698 | 5,085 | 189 | 11,732 | 82 | 310 | 75 |
| 1907..... | 390,322 | 151,848 | (*g*)29,520 | 29,268 | 204 | 12,547 | 98 | 381 | 126 |
| 1908..... | 423,940 | 224,740 | (*g*)45,235 | 88,396 | 559 | 17,116 | 161 | 616 | 201 |
| 1909..... | 374,088 | 147,459 | (*g*)48,344 | 34,025 | 7,560 | 20,697 | 230 | 599 | 57 |
| 1910..... | 307,190 | 185,604 | 51,869 | 44,277 | 6,354 | 17,065 | 411 | 574 | 139 |
| 1911..... | 469,552 | 112,907 | 53,590 | 32,687 | 1,200 | 17,238 | 299 | 622 | 108 |
| 1912..... | 629,587 | 244,532 | 64,621 | 48,137 | 3,075 | 17,068 | 403 | 448 | 94 |

| Year. | Magnesium Chloride. | Manganese Ore. | Millstones. | Mineral Paints. | Nickel, Old and Crude. | Nickel and Cobalt Ores | Nitric Acid. | Peat and Peat Coke. |
|---|---|---|---|---|---|---|---|---|
| 1899..... | 2,043 | 5,855 | 1,458 | 5,106 | 119 | 198 | 39 | 2,075 |
| 1900..... | 2,100 | 7,016 | 1,672 | 4,958 | 258 | 406 | 36 | 2,664 |
| 1901..... | 2,529 | 6,367 | 1,595 | 5,109 | 277 | 788 | 22 | 2,896 |
| 1902..... | 2,621 | 15,595 | 1,410 | 4,831 | 265 | 225 | 90 | 3,234 |
| 1903..... | 3,118 | 38,529 | 1,395 | 4,733 | 268 | 385 | 7 | 3,097 |
| 1904..... | 2,997 | 35,357 | 1,282 | 5,563 | 402 | 656 | 24 | 2,676 |
| 1905..... | 3,495 | 30,483 | 1,467 | 6,018 | 632 | 391 | 14 | 2,432 |
| 1906(*f*)... | 4,050 | 33,406 | 1,176 | 4,660 | 773 | *Nil.* | 12 | 1,918 |
| 1907..... | 5,006 | 70,067 | 1,469 | 6,043 | 1,192 | *Nil.* | 12 | 4,460 |
| 1908..... | 5,011 | 31,023 | 1,474 | 5,909 | 1,521 | 114 | 11 | 6,459 |
| 1909..... | 6,095 | 44,970 | 1,357 | 5,773 | 2,116 | *Nil.* | 30 | 5,993 |
| 1910..... | 6,616 | 59,951 | 1,510 | 7,340 | 1,606 | *Nil.* | 37 | 5,002 |
| 1911..... | 7,171 | 78,790 | 1,494 | 7,157 | 1,598 | 0.1 | 27 | 5,115 |
| 1912..... | 8,344 | 62,082 | 2,175 | 8,468 | 2,508 | 1.8 | 54 | 6,356 |

| Year. | Petroleum Products. | | | Phosphorus and Phosphoric Acid. | Potassium Salts. | | | Pyrites. |
|---|---|---|---|---|---|---|---|---|
| | Crude Oil. | Refined Oil. | Paraffin. | | Carbonate. | Chloride. | Chromate. | |
| 1899..... | 75,885 | 21,823 | 6,968 | 221 | 526 | 3,624 | 1 | 54,844 |
| 1900..... | 20,813 | 22,963 | 5,080 | 204 | 1,029 | 3,633 | 11 | 60,317 |
| 1901..... | 22,545 | 18,067 | 5,294 | 222 | 1,442 | 4,356 | 21 | 54,202 |
| 1902..... | 24,830 | 15,864 | 4,238 | 225 | 485 | 3,377 | 11 | 60,235 |
| 1903..... | 19,710 | 19,382 | 2,598 | 237 | 197 | 3,727 | 9 | 73,835 |
| 1904..... | 20,110 | 22,715 | 1,470 | 193 | 222 | 3,557 | 3 | 65,397 |
| 1905..... | 18,974 | 24,961 | 888 | 222 | 154 | 3,864 | 5 | 86,338 |
| 1906(*f*)..... | 13,522 | 9,693 | 403 | 178 | 602 | 3,729 | (*e*) 5 | 87,973 |
| 1907..... | 18,345 | 11,441 | 524 | 219 | 174 | 4,807 | (*e*)38 | 130,270 |
| 1908..... | 3,118 | 9,705 | 358 | 234 | 324 | 5,009 | (*e*)98 | 130,793 |
| 1909..... | 1,357 | 9,093 | 508 | 231 | 314 | 4,782 | (*e*)86 | 141,858 |
| 1910..... | 18,977 | 16,868 | 457 | 253 | 185 | 5,052 | 69 | 153,106 |
| 1911..... | 19,070 | 19,737 | 632 | 233 | 201 | 3,666 | 55 | 150,974 |
| 1912..... | 17,874 | 1,377 | 546 | 258 | 339 | 5,280 | 55 | 186,090 |

| Year. | Quicksilver *Kg.* | Salt. | Sand. | Silver. | | Slag and Slag Wool. | Roofing Slate. |
|---|---|---|---|---|---|---|---|
| | | | | Bullion, *Kg.* | Specie. | | |
| 1899..... | 2,600 | 37,883 | 71,279 | 28,900 | $112,056 | ..... | 15,562 |
| 1900..... | 1,300 | 39,822 | 77,930 | 29,300 | 199,955 | ..... | 13,047 |
| 1901..... | 2,600 | 39,625 | 83,401 | 41,800 | 207,669 | ..... | 11,555 |
| 1902..... | 1,300 | 46,128 | 92,617 | 177,900 | 237,104 | ..... | 14,378 |
| 1903..... | 1,600 | 48,793 | 94,492 | 150,400 | 250,299 | ..... | 11,531 |
| 1904..... | 2,500 | 94,103 | 97,364 | 36,700 | 420,413 | ..... | 9,170 |
| 1905..... | 2,400 | ..... | 104,195 | 36,100 | 143,152 | ..... | 8,852 |
| 1906(*f*)..... | 1,800 | 32,182 | 134,526 | 43,000 | 200,754 | 109,827 | 6,020 |
| 1907..... | 1,200 | 41,660 | 180,280 | 88,182 | 170,228 | 107,783 | 7,537 |
| 1908..... | 2,000 | 54,525 | 177,529 | 96,700 | 101,265 | 115,445 | 7,178 |
| 1909..... | 2,600 | 75,397 | 183,169 | 150,980 | 172,201 | 155,812 | 6,915 |
| 1910..... | 2,300 | 96,936 | 188,762 | 161,600 | 121,000 | 147,192 | 9,019 |
| 1911..... | 2,900 | 99,921 | 225,743 | 195,000 | 70,102 | 147,179 | 8,060 |
| 1912..... | 3,700 | 113,287 | 249,766 | 91,110 | 78,361 | 204,946 | 7,824 |

| Year. | Sodium Salts. | | | | | | Sulphur. |
|---|---|---|---|---|---|---|---|
| | Bi-sulphate. | Carbonate. | Carbonate (Calcined). | Hydrate. | Nitrate. | Sulphate. | |
| 1899 .. | 85 | 62 | 1,123 | 1,669 | 47,301 | 5,394 | 23,504 |
| 1900 .. | 73 | 104 | 1,141 | 1,836 | 54,559 | 5,110 | 27,795 |
| 1901 .. | 98 | 77 | 911 | 1,280 | 63,283 | 4,452 | 25,300 |
| 1902 .. | 17 | 97 | 312 | 1,030 | 39,958 | 5,997 | 23,878 |
| 1903 .. | 13 | 110 | 327 | 956 | 54,896 | 6,116 | 22,625 |
| 1904 .. | 103 | 103 | 1,109 | 659 | 54,887 | 5,409 | 30,505 |
| 1905 .. | 167 | 168 | 965 | 475 | 66,740 | 5,258 | 30,227 |
| 1906(f) | 86 | 382 | 303 | 218 | 49,862 | 7,508 | 26,755 |
| 1907 .. | 72 | 153 | 283 | 305 | 57,023 | 7,342 | 34,261 |
| 1908 .. | 32 | 124 | 288 | 358 | 69,722 | 7,596 | 30,985 |
| 1909 .. | 26 | 149 | 297 | 832 | 80,533 | 9,402 | 28,639 |
| 1910 .. | 15 | 224 | 354 | 341 | 81,781 | 10,150 | 34,936 |
| 1911 .. | 5 | 297 | 337 | 297 | 65,781 | 10,842 | 34,916 |
| 1912 .. | 10 | (i)455 | 260 | 302 | 92,838 | 14,454 | 40,913 |

| Year. | Sulphuric Acid. | Tin. Ingot, Crude, Old, etc. | Whet-stones. | Zinc. | | | |
|---|---|---|---|---|---|---|---|
| | | | | Calamine and Other Ores. | Spelter. | Bars, Sheets, Wires, etc. | White. |
| 1899..... | 10,245 | 3,005 | 3,717 | 12,730 | 15,225 | 481 | 750 |
| 1900..... | 10,643 | 3,439 | 3,643 | 14,181 | 17,844 | 667 | 875 |
| 1901..... | 11,712 | 3,671 | 3,445 | 18,403 | 16,921 | 579 | 718 |
| 1902..... | 12,474 | 3,638 | 3,599 | 20,723 | 17,034 | 651 | 636 |
| 1903..... | 16,148 | 3,564 | 3,774 | 22,344 | 17,973 | 746 | 698 |
| 1904..... | 19,878 | 3,528 | 4,272 | 24,039 | 20,787 | 731 | 840 |
| 1905..... | 17,320 | 3,845 | 4,376 | 22,890 | 21,874 | 568 | 972 |
| 1906(f)..... | 17,020 | 3,320 | 4,377 | 24,014 | 19,467 | 595 | 347 |
| 1907..... | 20,430 | 4,433 | 5,552 | 24,289 | 24,092 | 604 | 219 |
| 1908..... | 25,251 | 4,295 | 5,916 | 19,366 | 26,472 | 1,010 | 361 |
| 1909..... | 27,368 | 4,587 | 6,826 | 24,639 | 27,148 | 1,263 | 349 |
| 1910..... | 27,421 | 4,674 | 6,915 | 30,880 | 29,168 | 1,898 | 511 |
| 1911..... | 26,630 | 4,795 | 8,066 | 31,357 | 33,740 | 388 | 471 |
| 1912..... | 36,714 | 4,806 | 6,826 | 35,376 | 37,558 | 1,260 | 438 |

(a) From *Statistik des Auswaertigen Handels des Oesterreichisch-Ungarischen Zollgebiets.* (b) Includes arsenious acid and sulphide. (c) Includes burned asbestos. (d) The values of gold are figured at the rate of one crown = $0.203. (e) Potassium and Sodium. (f) Last 10 months only. (g) Metric tons. (h) Not including 188,884 tons of briquettes. (i) Includes bicarbonate.

# BELGIUM

The mining and metallurgical production in Belgium, and the imports and exports, according to the latest official statistics, are as follows:

MINERAL, METALLURGICAL AND QUARRY PRODUCTION OF BELGIUM. (a)

(In metric tons except where otherwise noted.)

| Year. | Barytes. | Chalk-marl. *Cubic Meters.* | Coal. | | Coke. | Flint. *Cubic Meters.* | Iron Ore. |
|---|---|---|---|---|---|---|---|
| | | | Bituminous. | Briquets. | | For Earthen-ware. | |
| 1899.... | 25,900 | 3,238,875 | 22,072,068 | 1,276,050 | 2,304,607 | 25,185 | 201,445 |
| 1900.... | 38,800 | 3,228,205 | 23,462,817 | 1,395,910 | 2,434,678 | 25,700 | 247,890 |
| 1901.... | 22,800 | 1,497,250 | 22,213,410 | 1,587,800 | 1,847,730 | 17,700 | 218,780 |
| 1902.... | 33,000 | 1,626,670 | 22,877,470 | 1,616,520 | 2,102,650 | 17,430 | 166,480 |
| 1903.... | 21,000 | 1,580,330 | 23,796,680 | 1,686,415 | 2,428,020 | 16,250 | 184,400 |
| 1904.... | 60,000 | 1,645,655 | (c)22,761,430 | 1,735,480 | 2,496,340 | 18,070 | 206,730 |
| 1905.... | 26,000 | 1,493,745 | 21,775,280 | 1,711,920 | 2,526,690 | 12,800 | 176,620 |
| 1906.... | 22,365 | 1,521,660 | 23,569,860 | 1,887,090 | 2,712,760 | 14,900 | 232,570 |
| 1907.... | 23,000 | 1,537,210 | 23,705,190 | 2,040,670 | 2,771,920 | 15,050 | 316,250 |
| 1908.... | 25,070 | 1,441,005 | 23,557,900 | 2,421,210 | 2,632,890 | 15,430 | 188,780 |
| 1909.... | 31,400 | 1,445,015 | 23,517,550 | 2,707,390 | 2,972,920 | 15,280 | 199,710 |
| 1910 ... | 4,900 | 1,546,750 | 23,916,560 | 2,651,190 | 3,110,820 | 16,400 | 122,960 |
| 1911.... | 25,200 | 1,667,125 | 23,053,540 | 2,778,620 | 3,160,950 | 10,950 | 150,500 |
| 1912.... | 32,400 | 1,745,070 | 22,972,140 | 2,690,510 | 3,175,500 | 5,930 | 167,370 |

| Year. | Iron, crude. | | | | | Iron and steel. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Foundry Pig. | Forge Pig. | Bessemer Pig. | Basic Pig. | Total Pig. | Ingots of Steel | Merchant Bars. | Beams & Special Bars. | Tires. |
| 1899.... | 84,165 | 317,029 | 169,664 | 453,718 | 1,024,576 | 731,249 | ..... | ..... | 11,212 |
| 1900.... | 88,335 | 305,344 | 176,557 | 447,271 | 1,018,561 | 655,199 | ..... | ..... | 11,934 |
| 1901.... | 86,170 | 178,250 | 166,820 | 332,940 | 764,180 | 515,780 | 334,910 | 186,200 | 12,380 |
| 1902.... | 104,540 | 254,710 | 199,170 | 510,630 | 1,069,050 | 769,040 | 380,990 | 223,380 | 12,790 |
| 1903.... | 91,600 | 256,890 | 229,160 | 638,430 | 1,216,080 | 969,230 | 446,360 | 138,270 | 17,810 |
| 1904.... | 99,350 | 224,410 | 217,390 | 742,040 | 1,287,597 | 1,065,870 | 543,260 | 268,360 | 23,540 |
| 1905.... | 98,170 | 206,390 | 220,210 | 784,850 | 1,311,120 | 1,200,430 | 570,130 | 299,840 | 25,810 |
| 1906.... | 96,090 | 218,225 | 177,900 | 870,860 | 1,375,775 | 1,440,860 | 552,850 | 346,420 | 32,070 |
| 1907.... | 92,280 | 189,190 | 88,650 | 1,008,170 | 1,406,980 | 1,521,610 | 594,170 | 327,930 | 34,700 |
| 1908.... | 76,290 | 116,740 | 78,950 | 996,870 | 1,270,050 | 1,249,620 | 544,810 | 241,060 | 29,000 |
| 1909.... | 91,040 | 127,080 | 56,430 | 1,340,060 | 1,616,370 | 1,580,350 | 628,740 | 291,260 | 33,960 |
| 1910.... | 82,410 | 115,760 | 55,650 | 1,596,970 | 1,852,090 | 1,892,160 | 672,730 | 340,850 | 31,860 |
| 1911.... | 52,970 | 102,690 | 46,240 | 1,836,720 | 2,046,280 | 2,128,170 | 711,220 | 380,160 | 35,450 |
| 1912.... | 94,810 | 66,940 | 44,250 | 2,093,480 | 2,301,290 | 2,442,420 | 609,930 | 390,340 | 40,320 |

| Year. | Iron and Steel. | | | | Lead. | | Manganese Ore. |
|---|---|---|---|---|---|---|---|
| | Rails. | Plates. | Sheets. | Total Wrought and Steel. | Ore. | Pig.(a) | |
| 1899 | 123,119 | ..... | ..... | 1,009,148 | 137 | 15,727 | 12,120 |
| 1900 | 134,428 | ..... | ..... | 926,752 | 230 | 16,365 | 10,820 |
| 1901 | 132,260 | 95,190 | 55,300 | 870,230 | 220 | 61,900 | 8,510 |
| 1902 | (c)268,220 | 101,280 | 67,350 | 1,106,950 | 164 | 73,357 | 14,440 |
| 1903 | (c)351,540 | 113,830 | 74,080 | 1,376,630 | 90 | 68,700 | 6,100 |
| 1904 | (c)266,900 | 126,960 | 79,040 | 1,378,750 | 91 | (f)23,470 | 485 |
| 1905 | 241,640 | 167,240 | 76,510 | 1,469,020 | 126 | 22,885 | *Nil.* |
| 1906 | 274,920 | 166,970 | 84,150 | 1,522,995 | 121 | 23,765 | 120 |
| 1907 | 314,760 | 148,690 | 82,420 | 1,575,110 | 210 | 27,450 | 2,100 |
| 1908 | (c)191,370 | 135,390 | 93,790 | 1,296,050 | 195 | 35,650 | 7,130 |
| 1909 | 214,000 | 170,750 | 112,160 | 1,569,560 | 150 | 40,306 | 6,270 |
| 1910 | 347,890 | 177,110 | 122,830 | 1,834,050 | 162 | 40,715 | *Nil.* |
| 1911 | 337,520 | 211,410 | 130,250 | 1,945,220 | 82 | 44,308 | *Nil.* |
| 1912 | 339,060 | 251,380 | 119,390 | 1,903,270 | 107 | 54,940 | *Nil.* |

| Year. | Mineral Paints. | Phosphate of Lime. | Pyrites. | Slate. *Pieces.* | Silver. *Kg.* | Zinc. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ochers. | | | | | Ore. (Blende) | Ore. (Calamine) | Spelter. | Sheets. |
| 1898 | (b) 290 | (b)156,920 | 147 | 42,311,000 | 116,035 | 7,350 | 4,125 | 119,671 | 35,587 |
| 1899 | (b) 300 | (b)190,090 | 283 | 44,167,000 | 134,854 | 5,736 | 3,730 | 122,843 | 34,289 |
| 1900 | (b) 300 | (b)215,670 | 400 | 43,941,000 | 146,548 | 5,715 | 3,000 | 119,317 | 38,825 |
| 1901 | 2,100 | 222,520 | 560 | 39,030,000 | 169,450 | 4,445 | 2,200 | 127,170 | 37,380 |
| 1902 | 200 | 135,850 | 760 | 37,120,000 | 212,922 | 3,568 | 284 | 124,780 | 37,070 |
| 1903 | 200 | 184,120 | 720 | 38,953,000 | 232,740 | 3,565 | 65 | 131,740 | 42,280 |
| 1904 | 450 | 202,480 | 1,075 | 41,240,000 | 252,920 | 3,698 | 4 | 137,323 | 41,490 |
| 1905 | 300 | 193,305 | 976 | 41,435,000 | 201,935 | 3,929 | *Nil.* | 142,555 | 45,320 |
| 1906 | 250 | 152,140 | 908 | 43,801,000 | 173,535 | 3,858 | *Nil.* | 148,035 | 44,525 |
| 1907 | 200 | 181,230 | 397 | 40,102,000 | 178,020 | 3,485 | 5 | 152,370 | 45,330 |
| 1908 | ..... | 198,030 | 357 | 41,180,000 | 228,000 | 2,099 | 3 | 161,940 | 43,410 |
| 1909 | 700 | 205,260 | 214 | 41,630,000 | 271,270 | 1,229 | *Nil.* | 174,490 | 44,850 |
| 1910 | 600 | 202,880 | 214 | 36,440,000 | 264,655 | 1,434 | *Nil.* | 181,745 | 47,970 |
| 1911 | 540 | 196,780 | 122 | 37,620,000 | 252,720 | 836 | *Nil.* | 198,230 | 48,450 |
| 1912 | 650 | 203,110 | 148 | 29,600,000 | 279,960 | 1,167 | *Nil.* | 205,940 | 49,120 |

(a) From *Statistique des Industries Extractives et Metallurgiques et des Appareils à vapeur en Belgique.*
(b) Cubic meters. (c) Includes beams. (d) Not including 48,595 tons imported silver lead treated.
(e) Net production from this year on. (f) Domestic lead only beginning with this year.

# CANADA

The statistics of mineral production in the Dominion of Canada as reported by the Geological Survey are summarized in the following tables. The statement of imports and exports for 1907 is for the nine months ending March 31, in consequence of a change in the law whereby the fiscal year was changed from June 30:

MINERAL PRODUCTION OF THE DOMINION OF CANADA. (*a*)
(In metric tons or dollars.)

| Year. | Arsenic. | Asbestos and Asbestic. | Barytes. | Cement—*Barrels.*(*j*) | | Chromite. | Coal. | Cobalt. | Coke. (*k*) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Natural Rock. | Portland. | | | | |
| 1899.... | 52 | 22,938 | 653 | 131,387 | 255,366 | 1,796 | 4,467,021 | ..... | 91,444 |
| 1900.... | 275 | 27,797 | 1,213 | 125,428 | 292,124 | 2,335 | 5,087,060 | ..... | 142,521 |
| 1901.... | 630 | 36,477 | 592 | 133,328 | 317,066 | 1,274 | 5,648,208 | ..... | 331,537 |
| 1902.... | 726 | 36,657 | 994 | 127,931 | 594,594 | 900 | 6,524,180 | ..... | 455,353 |
| 1903.... | 725 | 37,902 | 1,055 | 92,252 | 627,741 | 3,509 | 6,933,107 | ..... | 509,115 |
| 1904.... | (*d*) 66 | 44,131 | 1,253 | 51,555 | 771,650 | 5,511 | 6,812,834 | ..... | 493,107 |
| 1905.... | *Nil.* | 61,928 | 3,049 | 14,184 | 1,346,547 | 7,781 | 7,961,397 | ..... | 622,154 |
| 1906.... | *Nil.* | 72,025 | 3,628 | 8,610 | 2,139,164 | 7,936 | 9,033,973 | ..... | (*b*) |
| 1907.... | 317 | 82,117 | 1,829 | 5,775 | 2,368,593 | 6,527 | 9,533,442 | ..... | (*b*) |
| 1908.... | 634 | 82,448 | 3,911 | 1,044 | 2,665,289 | 7,341 | 9,857,754 | 841 | 784,788 |
| 1909.... | 1,024 | 79,197 | (*b*) | (*b*) | 4,067,709 | 2,240 | 9,526,938 | (*i*) | 782,016 |
| 1910.... | 1,362 | 92,800 | (*b*) | (*b*) | 4,753,975 | 276 | 11,711,000 | (*i*) | 818,450 |
| 1911.... | 1,902 | 115,136 | 45 | (*b*) | 5,692,915 | 143 | 10,243,528 | (*i*) | 848,280 |
| 1912.... | 1,855 | 119,078 | (*b*) | (*b*) | 7,120,787 | (*b*) | 13,335,710 | (*i*) | 1,280,249 |

| Year. | Copper. (In Ore, etc.) | Corundum. | Feldspar. | Gold. (*c*) | Graphite. | Grindstones. | Gypsum. | Iron Ore. | Iron, Pig. All kinds. |
|---|---|---|---|---|---|---|---|---|---|
| 1899.. | 6,838 | (*b*) | 2,721 | $21,261,584 | 1,188 | 4,091 | 221,821 | 67,678 | 93,367 |
| 1900.. | 8,588 | 3 | 288 | 27,908,153 | 1,743 | 5,024 | 228,656 | 110,654 | 87,594 |
| 1901.. | 17,155 | 403 | 4,852 | 24,128,503 | 2,004 | 4,155 | 266,476 | 284,477 | 248,859 |
| 1902.. | 17,598 | 697 | 6,871 | 21,336,667 | 993 | 5,835 | 301,165 | 366,431 | 324,617 |
| 1903.. | 19,357 | 880 | 12,633 | 18,843,590 | 660 | 5,023 | 285,242 | 239,715 | 270,182 |
| 1904.. | 19,497 | 834 | 10,057 | 16,400,000 | 410 | 4,091 | 309,133 | 317,387 | 275,367 |
| 1905.. | 21,596 | 1,492 | 10,617 | 14,486,833 | 491 | 4,693 | 395,341 | 263,113 | 475,491 |
| 1906.. | 25,863 | 2,063 | 14,397 | 12,023,932 | 405 | 5,029 | 378,904 | 269,842 | 550,628 |
| 1907.. | 26,025 | 1,716 | 11,414 | 8,264,765 | 525 | 4,881 | 431,286 | 283,820 | 590,444 |
| 1908.. | 28,895 | 988 | 7,144 | 9,842,105 | 227 | 3,285 | 309,254 | 215,986 | 572,284 |
| 1909.. | 23,811 | 1,353 | 11,594 | 9,382,230 | 783 | 3,877 | 429,218 | (*d*) 243,167 | (*g*)686,886 |
| 1910.. | 25,262 | 1,696 | 14,114 | 10,205,835 | 1,263 | 3,604 | 476,496 | (*d*) 235,342 | (*g*)726,471 |
| 1911.. | 25,250 | 1,336 | 16,074 | 9,762,096 | 1,151 | 4,818 | 458,550 | 190,823 | 832,376 |
| 1912.. | 26,493 | 1,778 | 11,098 | 12,557,252 | 1,869 | 2,642 | 522,996 | 107,166 | 920,064 |

| Year. | Iron and Steel, Rolled. | Lead. (In ore, etc.) | Manganese Ore. | Mica. | Mineral Paints. (Ochers.) | Natural Gas. | Nickel. (In ore, etc.) | Petroleum, Crude. *Barrels.* (*e*) |
|---|---|---|---|---|---|---|---|---|
| 1899.... | 112,412 | 9,914 | 1,434 | $163,000 | 3,555 | 387,271 | 2,605 | 808,570 |
| 1900.... | 102,301 | 28,648 | 27 | 166,000 | 1,783 | 417,094 | 3,211 | 710,498 |
| 1901.... | 113,799 | 23,537 | (*d*)399 | 160,000 | 2,025 | 339,476 | 4,167 | 623,392 |
| 1902.... | 164,069 | 10,411 | (*d*)156 | 135,904 | 4,494 | 195,992 | 4,849 | 530,624 |
| 1903.... | 131,588 | 8,226 | 83 | 177,857 | 5,683 | 202,210 | 5,671 | 486,637 |
| 1904.... | (*b*) | 17,241 | (*d*)112 | 152,919 | 3,562 | 247,370 | 4,786 | 552,575 |
| 1905.... | (*b*) | 25,391 | (*d*) 20 | 168,170 | 4,632 | 314,249 | 8,565 | 634,095 |
| 1906.... | (*b*) | 24,580 | (*d*) 84 | (*d*)581,043 | 6,201 | 528,868 | 9,745 | 569,753 |
| 1907.... | (*b*) | 21,570 | ..... | 333,022 | 7,115 | 748,541 | 9,610 | 788,872 |
| 1908.... | (*h*)534,117 | 19,593 | ..... | 139,871 | 4,305 | 1,012,660 | 8,685 | 527,987 |
| 1909.... | (*h*)684,670 | 20,801 | ..... | 147,782 | 3,573 | 1,207,029 | 11,922 | 420,755 |
| 1910.... | (*h*)745,963 | 14,963 | ..... | 190,385 | 4,365 | 1,346,471 | 16,905 | 315,895 |
| 1911 ... | (*h*)800,722 | 10,617 | 5 | 119,863 | 3,285 | 1,917,673 | 15,457 | 291,092 |
| 1912.... | ..... | 16,222 | 68 | 104,393 | 5,129 | 2,311,126 | 20,340 | 243,336 |

| Year. | Phosphate (Apatite). | Pyrites. | Salt. | Silver—*Kg.* (In ore, etc.) | Soapstone and Talc. |
|---|---|---|---|---|---|
| 1899 | 2,721 | 25,112 | 53,820 | 106,116 | 408 |
| 1900 | 1,283 | 36,308 | 56,284 | 138,980 | 1,288 |
| 1901 | 937 | 31,982 | 53,901 | 172,292 | 235 |
| 1902 | 776 | 32,304 | 58,462 | 133,478 | 625 |
| 1903 | 1,205 | 30,822 | 56,644 | 99,489 | 898 |
| 1904 | 832 | 29,980 | 62,411 | 115,666 | 762 |
| 1905 | 1,180 | 29,713 | 41,159 | 185,839 | 454 |
| 1906 | (*b*) | 35,927 | 69,283 | 266,521 | 1,119 |
| 1907 | 680 | 35,494 | 65,936 | 390,359 | 1,391 |
| 1908 | 1,447 | 42,934 | 72,537 | 687,504 | 976 |
| 1909 | 905 | 58,645 | 76,237 | 856,263 | 3,945 |
| 1910 | 1,341 | 48,871 | 76,286 | 1,022,350 | 6,450 |
| 1911 | 506 | 74,994 | 83,083 | 1,018,352 | 6,621 |
| 1912 | ..... | 72,306 | 86,236 | 993,210 | 7,503 |

(*a*) From *Reports Compiled by the Geological Survey of Canada.* (*b*) Not reported. (*c*) Gold values are calculated at the rate of $20.67 per oz. (*d*) Export. (*e*) One barrel contains 35 imp. gal. (*g*) From Canadian ore, 149,444 short tons in 1909, 104,906 tons in 1910, 42,186 tons in 1911, and 36,355 tons in 1912. (*h*) Steel ingots and castings. (*i*) 1909, $94,609; 1910, $51,986; 1911, $221,790; $319,785 in 1912 for oxides; values received. (*j*) Bbl. of 350 lb. each, sold or shipped. (*k*) Including that from foreign coal.

## MINERAL IMPORTS OF THE DOMINION OF CANADA. (*a*)

(In metric tons or dollars.)

| Year. (*b*) | Aluminum. | | Antimony. (*c*) | Arsenic. | Asbestos. (*d*) | Asphalt. | Cement. |
|---|---|---|---|---|---|---|---|
| | Manufactures. (*m*) | Ingots, Sheets, etc. | | | | | |
| 1900 | $12,543 | ..... | 90 | 105 | $43,455 | 2,825 | $513,770 |
| 1901 | 16,202 | ..... | 159 | 72 | 50,829 | 2,849 | 666,350 |
| 1902 | 30,496 | ..... | 229 | 48 | 52,464 | 3,426 | 863,646 |
| 1903 | 14,201 | $ 13,930 | 393 | 135 | 75,465 | 3,037 | 890,745 |
| 1904 | 16,065 | 101,427 | 190 | 188 | 83,827 | 7,093 | 1,014,713 |
| 1905 | 28,418 | 154,569 | 85 | 122 | 116,836 | 5,096 | 1,263,828 |
| 1906 | 23,565 | 168,405 | 183 | 202 | 138,000 | 7,178 | 1,003,022 |
| 1907(*o*) | 20,656 | 218,399 | 146 | 158 | 127,509 | 11,929 | 540,006 |
| 1908(*r*) | 37,197 | 131,762 | 220 | 228 | 191,204 | 14,113 | 865,275 |
| 1909(*r*) | 30,076 | 167,019 | 201 | 58 | 181,710 | 15,979 | 473,211 |
| 1910(*r*) | 42,493 | 424,006 | 232 | 12 | 198,756 | 19,661 | 159,040 |
| 1911 (*r*) | 83,638 | 782,254 | 257 | 115 | 254,331 | 23,248 | (*f*) 494,446 |
| 1912(*r*) | 119,070 | 487,490 | 233 | 159 | 349,655 | 28,291 | (*f*) 936,425 |
| 1913(*r*) | 126,531 | 403,700 | 400 | 259 | 497,160 | 47,353 | (*f*) 1,955,177 |

| Year. | Coal. | | Coke. | Copper. | Copper, Sulphate. | Gold and silver. |
|---|---|---|---|---|---|---|
| | Anthracite. (*f*) | Bituminous. (*f*) | | Ingots, Pig and Scrap. | | Coin and Bullion. (*g*) |
| 1900 | 1,500,542 | 2,512,334 | 170,405 | 519 | 752 | $8,297,438 |
| 1901 | 1,753,488 | 2,658,257 | 280,069 | 432 | 673 | 3,537,294 |
| 1902 | 1,498,773 | 3,208,005 | 242,298 | 801 | 711 | 6,311,405 |
| 1903 | 1,320,239 | 3,684,502 | 232,848 | 924 | 1,010 | 8,976,797 |
| 1904 | 2,064,444 | 4,230,436 | 200,590 | 960 | 795 | 7,874,313 |
| 1905 | 2,361,952 | 4,377,667 | 337,035 | 882 | 934 | 10,308,435 |
| 1906 | 1,996,183 | 5,003,029 | 435,561 | 1,191 | 844 | 7,078,603 |
| 1907(*o*) | 1,260,723 | 4,022,843 | 363,286 | 1,186 | 897 | 7,029,047 |
| 1908(*r*) | 2,803,681 | 7,681,464 | 561,677 | 1,638 | 1,161 | 6,548,661 |
| 1909(*r*) | 2,775,680 | 6,526,797 | 423,013 | 1,239 | 963 | 9,988,442 |
| 1910(*r*) | 2,860,196 | 10,382,156 | 636,888 | 2,329 | 859 | 6,017,589 |
| 1911 (*r*) | 3,144,130 | 7,785,259 | 692,292 | 2,279 | 772 | 10,206,210 |
| 1912(*r*) | 3,736,169 | 9,526,138 | 582,331 | 2,514 | 930 | 26,033,881 |
| 1913(*r*) | 3,844,062 | 10,034,383 | 644,207 | 2,581 | 1,153 | 5,527,979 |

| ar. | Graphite. | | Gypsum. | | Iron and Steel. | | |
|---|---|---|---|---|---|---|---|
| | Crude. | Manufactures. (*h*) | Crude and Ground. | Plaster of Paris. | Pig and Scrap. | Slabs, Blooms Bars, etc. | Alloys of Iron. |
| ..... | 2,357 | 75,536 | 289 | 228 | 59,033 | 10,659 | 1,372 |
| ..... | 3,649 | 64,123 | 516 | 215 | 71,882 | 18,208 | 5,910 |
| ..... | 2,870 | 69,676 | 1,007 | 286 | 129,641 | 17,896 | 5,762 |
| ..... | 1,802 | 67,563 | 626 | 291 | 86,087 | 9,088 | 2,700 |
| ..... | 2,499 | 75,288 | 2,972 | 3,595 | 90,698 | 14,420 | 11,738 |
| ..... | 2,791 | 86,028 | 5,743 | 6,579 | 112,937 | 29,520 | 13,626 |
| ..... | 3,176 | 57,430 | 8,334 | 9,730 | 137,654 | 17,369 | 17,785 |
| ..... | 3,030 | 78,380 | 8,519 | 6,955 | 190,994 | 35,534 | 16,139 |
| ..... | 1,408 | 75,608 | 9,359 | 7,712 | 62,967 | 43,263 | 13,571 |
| ..... | 5,223 | 95,900 | 3,618 | 19,095 | 159,515 | 97,036 | 14,471 |
| ..... | 4,300 | 97,057 | 11,443 | 19,664 | 266,269 | 139,060 | 15,773 |
| ..... | 6,163 | 84,240 | 2,130 | 9,313 | 214,046 | 80,250 | 16,578 |
| ..... | 6,105 | 89,719 | 8,800 | 28,975 | 306,927 | 77,176 | 20,837 |

| Kainite. | Lead. | | | | Lime. | | Mineral Paints (Ochers). |
|---|---|---|---|---|---|---|---|
| | Pig and Scrap. | Bars and Sheets. | Litharge. | Pigments and Zinc White. | Burned. *Barrels.* | Chloride of. | |
| 88 | (*i*)3,871 | 739 | 505 | 4,647 | 19,657 | 1,605 | 1,031 |
| 85 | (*i*)5,548 | 844 | 590 | 7,071 | 24,602 | 1,806 | 1,148 |
| 259 | (*i*)4,471 | 523 | 632 | 8,715 | 31,108 | 2,104 | 1,459 |
| 339 | 4,292 | ..... | ..... | 7,679 | 54,359 | 2,080 | 1,256 |
| 306 | 2,589 | 800 | 811 | 9,695 | 98,676 | 2,507 | 1,417 |
| 306 | 3,751 | 730 | 461 | 6,947 | 134,334 | 2,645 | 809 |
| 511 | 3,811 | 622 | 513 | 2,215 | 88,919 | 2,302 | 570 |
| 743 | 2,902 | 782 | 864 | 5,743 | 129,379 | 3,421 | 788 |
| 562 | 2,273 | 623 | 550 | 3,998 | 153,934 | 2,697 | 546 |
| 687 | 5,755 | 580 | 915 | 4,433 | 191,527 | 4,554 | 914 |
| 339 | 5,292 | 707 | 750 | 5,312 | 176,730 | 4,745 | 1,169 |
| 262 | 10,934 | 1,356 | 745 | 4,921 | 230,013 | 5,584 | 1,358 |
| 19 | 10,980 | 918 | 1,197 | 6,627 | 360,242 | 5,248 | 1,649 |

| r. | Nickel. | Petroleum Products. | | Platinum. | Potassium Salts. | | Quicksilver. |
|---|---|---|---|---|---|---|---|
| | | Illuminating Oil etc., Crude or Refined. *Gallons.* | Paraffin Wax and Candles. | | Except Saltpeter. | Saltpeter. | |
| ..... | 12,029 | 11,082,822 | 74 | 20,263 | 476 | 581 | 64 |
| ..... | 15,448 | 13,220,005 | 123 | 19,357 | 771 | 690 | 44 |
| ..... | 26,177 | 18,799,312 | 307 | 21,251 | 1,060 | 916 | 75 |
| ..... | 14,682 | 24,521,115 | 228 | 28,112 | 1,151 | 898 | 69 |
| ..... | 19,076 | 13,229,855 | 98 | 61,719 | 945 | 1,048 | 47 |
| ..... | 15,976 | 10,981,611 | 375 | 54,494 | 1,317 | 1,141 | 68 |
| .... | 19,461 | 8,066,403 | 189 | 113,967 | 1,074 | 638 | 44 |
| .... | ..... | 8,844,129 | 102 | 63,582 | 3,396 | 2,653 | 81 |
| .... | (*s*)67,107 | 13,095,593 | 103 | 47,371 | 1,570 | 925 | 42 |
| .... | (*s*)98,238 | (*u*)48,384,763 | 253 | 80,180 | 2,497 | 665 | 129 |
| ..... | 137,114 | (*u*)66,119,105 | 931 | 136,823 | 3,152 | 1,490 | 59 |
| ..... | 135,227 | 88,916,283 | 808 | 190,770 | 3,734 | 1,049 | 49 |
| ..... | 194,079 | 164,013,894 | 892 | 221,300 | 5,643 | 835 | 67 |

| Year. | Sal-Ammoniac. | Salt. | Silex. | Sodium Salts Except Chloride. | Sulphur. | Tin and Tinware. | Zinc. |
|---|---|---|---|---|---|---|---|
| 1901 | 76 | 103,402 | 162 | 18,631 | 10,827 | $2,339,109 | 931 |
| 1902 | 78 | 114,629 | 199 | 17,133 | 11,180 | 2,293,958 | 1,582 |
| 1903 | 114 | 112,188 | 159 | 18,887 | 11,077 | 2,712,168 | 1,209 |
| 1904 | 93 | 103,635 | 252 | 25,118 | 8,786 | 2,389,557 | 1,540 |
| 1905 | 143 | 97,723 | 405 | 26,219 | 10,633 | 2,791,757 | 1,721 |
| 1906 | 209 | 99,788 | 338 | 30,401 | 19,512 | 3,105,876 | 3,383 |
| 1907(o) | 130 | 73,156 | 542 | 25,068 | 11,725 | 2,473,572 | 2,761 |
| 1908(r) | 172 | 105,286 | 1,131 | 39,154 | 23,494 | 1,619,647 | 2,521 |
| 1909(r) | 162 | 119,660 | 417 | 33,787 | 19,981 | 2,984,065 | 2,993 |
| 1910(r) | 303 | 121,473 | 582 | 47,913 | 19,484 | 3,512,615 | (v)7,606 |
| 1911(r) | 346 | 111,174 | 468 | 62,969 | 22,935 | 4,235,848 | (v)6,069 |
| 1912(r) | 377 | 119,114 | 337 | 74,016 | 20,430 | 3,710,102 | 7,217 |
| 1913(r) | 544 | 100,494 | 658 | 98,561 | 32,984 | 3,055,943 | 9,397 |

**EXPORTS OF DOMESTIC MINERAL PRODUCE FROM THE DOMINION OF CANADA (s)**
(In metric tons or dollars.)

| Year (b). | Antimony Ore. | Asbestos. | Chromite. | Coal. | Coke. | Copper (s). |
|---|---|---|---|---|---|---|
| 1901 | 219 | 24,242 | (k)2,049 | 1,713,737 | 60,129 | 11,954 |
| 1902 | 13 | 30,011 | (k) 672 | 1,649,278 | 52,873 | 13,789 |
| 1903 | 128 | 27,823 | 658 | 1,796,689 | 39,616 | 13,445 |
| 1904 | 87 | 31,444 | 2,103 | 1,494,106 | 61,750 | 20,279 |
| 1905 | 340 | 37,320 | 3,702 | 1,465,809 | 116,387 | 17,431 |
| 1906 | 388 | 40,367 | 1,640 | 1,651,203 | 50,004 | 20,082 |
| 1907(o) | 832 | 37,194 | 604 | 1,165,809 | 44,669 | 11,845 |
| 1908(r) | 693 | 53,543 | 1,585 | 1,702,673 | 50,343 | 25,824 |
| 1909(r) | 1 | 54,188 | 3,707 | 1,548,468 | 70,024 | 24,642 |
| 1910(r) | 33 | 58,083 | 1,052 | 1,822,398 | 44,343 | 26,107 |
| 1911(r) | 222 | 63,348 | 14 | 2,100,309 | 54,380 | 24,950 |
| 1912(r) | 1 | 69,233 | ..... | 1,436,798 | 13,677 | 25,595 |
| 1913(r) | ..... | 83,299 | ..... | 1,920,809 | 56,271 | 36,717 |

| Year. | Gold. Quarts, Dust, etc. | Graphite. | Grindstones. | Gypsum crude. | Iron ore. | Lead (p). |
|---|---|---|---|---|---|---|
| 1901 | $24,445,156 | 1,246 | $38,304 | 156,080 | (n) 54,208 | 29,747 |
| 1902 | 19,668,015 | 783 | 21,878 | 243,629 | (n)478,503 | 13,890 |
| 1903 | 16,437,528 | 530 | 14,169 | 271,899 | (n)267,000 | 7,386 |
| 1904 | 18,715,539 | 269 | 12,676 | 247,741 | (n)214,309 | 7,329 |
| 1905 | 15,208,380 | 201 | 27,985 | 290,574 | 204,091 | 23,094 |
| 1906 | 12,991,916 | 180 | 15,793 | 367,203 | 134,270 | 6,158 |
| 1907(o) | 7,226,954 | 3 | 33,929 | 249,780 | 31,011 | 8,330 |
| 1908(r) | 8,817,041 | 167 | 28,726 | 340,235 | 23,863 | 12,650 |
| 1909(r) | 7,392,610 | 396 | 18,019 | 239,139 | 3,568 | 5,459 |
| 1910(r) | 6,110,473 | 1,164 | 13,754 | 304,736 | 28,608 | 8,395 |
| 1911(r) | 5,344,465 | 362 | 23,914 | 325,928 | 95,080 | 1,451 |
| 1912(r) | 7,211,438 | 1,395 | 30,513 | 324,324 | 34,162 | 52 |
| 1913(r) | 11,231,476 | 1,572 | 27,375 | 344,183 | 123,004 | 93 |

| Year. | Manganese Ore. | Mica. | Nickel in Ore, Matte, etc. | Petroleum, Crude and Refined. | Pyrites. | Salt. *Bushels.* | Silver, *Kg.* (in ore, matte, etc). |
|---|---|---|---|---|---|---|---|
| 1901 ..... | 33 | 444 | 4,327 | 19,942 | 22,146 | 56,461 | 125,110 |
| 1902 ..... | 500 | 452 | 1,762 | 2,478 | 24,088 | 21,778 | 114,610 |
| 1903 ..... | 137 | 632 | 4,098 | 413 | 16,762 | 7,959 | 100,861 |
| 1904 ..... | 62 | 393 | 6,456 | 1,208 | 15,582 | 42,662 | 99,472 |
| 1905 ..... | 84 | 461 | 5,431 | 6,441 | 20,473 | 5,663 | 112,076 |
| 1906 ..... | 15 | 603 | 10,866 | 1,741 | 18,398 | 23,168 | 203,323 |
| 1907(o)... | 84 | 631 | 7,355 | (q)3,167 | 20,148 | 5,113 | 274,178 |
| 1908(r)... | 1 | 409 | 8,596 | (q)3,389 | 17,835 | 35,543 | 515,161 |
| 1909(r)... | 3 | 243 | 8,895 | (q)195 | 23,087 | (w)3,040 | 733,248 |
| 1910(r)... | 5 | 397 | 13,891 | (q)9,093 | 24,439 | (w)6,088 | 932,098 |
| 1911(r)... | 2 | 370 | 15,771 | (q)1,493 | 32,396 | (w)6,625 | 1,049,153 |
| 1912(r)... | 12 | 348 | 15,073 | 38,663 | 25,279 | 109,963 | 960,586 |
| 1913(r)... | 7 | 415 | 21,849 | ‡152,746 | 3,109 | 60,536 | 1,096,835 |

(a)From Tables of the *Trade and Navigation of the Dominion of Canada.* (b) Fiscal year endign June 30. (c) Includes regulus and salts of antimony. (d) Asbestos in any form except crude, and all manufactures of. (e) Includes copper in ore, matte, regulus, etc. (f) Includes coal dust. (g) Coin, gold and silver, except U. S. silver coin. (h) Includes black lead and crucibles (clay or graphite). (i) Includes Canadian lead ore refined in the United States. (k) Calendar year. (m) Unclassified. (n) Includes chromic iron ore. (o) Returns for the 9 months of the fiscal year ending March 31. (p) Includes lead contained in ore, etc. (q) Gallons. (r) Fiscal year ending March 31. (s) Includes silver-nickel and German silver. (t) Weight, 64,176 tons; 46,821 and 247,940 net tons. (u) Includes all oils. (v) Not including manufactures. (w) Using 60 lbs. per bushel.

# CHINA

The official statistics of mineral imports and exports are summarized in the following table:

MINERAL IMPORTS OF CHINA. (a)

(In metric tons.)

| Year. | Brass and Yellow Alloys. | Copper. | Lead. | Nickel. | Petroleum, Gal. | Quicksilver. | Tin. | Tinplate. | Zinc. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Spelter. | Sheet, etc. |
| 1909 (c) | 1,516 | 1,012 | 8,198 | 127 | 145,719,886 | 40 | 3,076 | 11,774 | 113 | 727 |
| 1910... | 1,674 | 2,428 | 9,247 | 134 | 161,399,583 | 51 | 2,684 | 11,569 | ..... | 858 |
| 1911... | 1,244 | 4,408 | 8,138 | 39 | 235,898,240 | 49 | 1,994 | 21,676 | 81 | 769 |
| 1912... | 970 | 7,368 | 6,187 | 56 | 197,902,362 | 49 | 2,548 | 21,036 | 443 | 861 |

MINERAL EXPORTS OF CHINA. (a)

(In metric tons.)

| Year. | Antimony. | | Iron. | | Lead. | | Quicksilver. | Tin. | Zinc. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ore. | Metal(b) | Ore. | Pig and Mnfd. | Ore. | Pig. | | | Ore. | Spelter. |
| 1909..... | 776 | 7,937 | 89,100 | 38,714 | 4,039 | 12 | 51 | 4,516 | 7,578 | 242 |
| 1910..... | 5,762 | 6,643 | 132,561 | 65,381 | 5,176 | 3 | 48.5 | 6,510 | 9,786 | 328 |
| 1911..... | 6,812 | 6,986 | 112,295 | 70,906 | 5,410 | 11.2 | 18.5 | 6,056 | 4,599 | 710 |
| 1912..... | 2,054 | 13,531 | 355,538 | 12,604 | 4,276 | 20 | 4.3 | 8,786 | 7,170 | 760 |

(a) From annual reports of the Imperial Chinese Maritime Customs. (b) Regulus and refined. (c) Reported jointly by U. S. Consuls at Hongkong and Tientsin. (d) Through Consul General Anderson, Hongkong, figures directly from the Inspectorate General of Customs at Shanghai.

# FRANCE

In the following tables are given the statistics of mineral and metal production in France and the French colonies—Algeria, New Caledonia and Tunis—together with the foreign commerce of France in mineral and metal products:

MINERAL AND METALLURGICAL PRODUCTION OF FRANCE. (*a*)
(In metric tons.)

| Year. | Aluminum. | Antimony. | | Arsenic Ore. | Asphaltum. | Barytes. | Bauxite. | Bitumen. (*c*) | Cement. |
|---|---|---|---|---|---|---|---|---|---|
| | | Ore. | Metal. | | | | | | |
| 1899..... | 763 | 7,392 | 1,499 | 2,600 | 22,100 | 4,058 | 48,215 | 258,449 | 1,144,271 |
| 1900..... | 1,026 | 7,843 | 1,573 | 4,705 | 25,228 | 3,635 | 58,530 | 266,474 | 1,147,670 |
| 1901..... | 1,200 | 9,867 | 1,786 | 7,491 | 20,391 | 4,145 | 76,620 | 249,655 | 1,127,206 |
| 1902..... | 1,355 | 9,715 | 1,725 | 5,372 | ..... | 4,323 | 96,900 | 258,295 | 962,930 |
| 1903..... | 1,570 | 12,380 | 2,748 | 6,658 | ..... | 5,731 | 133,890 | 243,295 | 898,393 |
| 1904..... | 1,650 | 9,065 | 2,116 | 3,117 | 22,000 | 6,944 | 75,640 | 227,177 | 903,632 |
| 1905..... | 1,905 | 12,543 | 2,396 | 3,627 | 20,000 | 5,504 | 103,207 | 188,403 | 922,531 |
| 1906..... | 3,396 | 18,567 | 3,433 | 6,534 | 38,231 | 11,680 | 117,781 | 196,375 | 1,257,861 |
| 1907..... | 4,700 | 24,000 | 3,950 | 7,900 | 33,000 | 11,150 | 158,000 | 177,000 | 1,253,546 |
| 1908..... | 4,681 | 26,026 | 3,850 | 2,381 | 41,000 | 16,277 | 170,679 | 171,158 | 1,359,658 |
| 1909..... | 6,092 | 28,105 | 5,444 | 2,141 | 44,800 | 14,111 | 130,149 | 169,000 | 1,374,574 |
| 1910..... | 6,425 | 28,130 | 4,640 | 8,045 | 38,500 | 11,632 | 196,056 | 169,769 | 1,521,131 |
| 1911..... | 7,400 | 29,267 | 4,775 | 19,000 | 39,000 | 10,064 | 4,831 | 170,000 | 1,795,000 |

| Year. | Coal. | Lignite. | Peat. | Copper. | | Gold. | Gypsum. | |
|---|---|---|---|---|---|---|---|---|
| | | | | Ore. | Metal. | | Crude. | Calcined. |
| 1900..... | 32,721,562 | 682,736 | 95,630 | 3,031 | 6,446 | $134,904 | 192,916 | 1,405,845 |
| 1901..... | 31,633,300 | 691,700 | 118,433 | 3,413 | 7,000 | 85,727 | 355,995 | 1,623,710 |
| 1902..... | 29,365,047 | 632,423 | 109,941 | 828 | 6,300 | (*b*) | 219,487 | 1,572,687 |
| 1903..... | 34,217,661 | 688,757 | 100,348 | 10,892 | 6,921 | (*b*) | 162,766 | 1,468,830 |
| 1904..... | 33,502,394 | 665,572 | 95,716 | 2,756 | 6,900 | (*b*) | 106,173 | 1,481,303 |
| 1905..... | 35,218,000 | 709,000 | 98,500 | 5,068 | 7,576 | 235,447 | 78,832 | 1,299,313 |
| 1906..... | 33,458,000 | 738,000 | 92,469 | 2,547 | 5,770 | 511,665 | 79,568 | 1,297,861 |
| 1907..... | 35,989,000 | 765,000 | 90,952 | 2,400 | 7,800 | 847,290 | 87,370 | 1,316,567 |
| 1908..... | 36,633,000 | 751,000 | 79,759 | 766 | 7,935 | 960,666 | 92,898 | 1,326,131 |
| 1909..... | 37,115,500 | 724,500 | 78,600 | 458 | 7,823 | 1,147,400 | 76,057 | 1,263,692 |
| 1910..... | 37,634,893 | 715,000 | 48,415 | 222 | 12,933 | (*h*) 1,706,580 | 64,181 | 1,533,298 |
| 1911..... | 38,521,000 | 709,000 | 58,521 | 35 | 13,200 | (*h*) 1,463,519 | 59,648 | 1,640,698 |
| 1912..... | 40,560,097 | 748,483 | ..... | ..... | ..... | ..... | ..... | ..... |

| Year. | Iron. | | | | Lead. | | Lime. | Manganese Ore. | Millstones. |
|---|---|---|---|---|---|---|---|---|---|
| | Ore. | Pig. | Wrought. Iron. | Wrought. Steel. | Ore. (*d*) | Pig. (*e*) | | | |
| 1900. | 4,676,740 | 2,714,298 | 672,172 | 1,226,537 | 24,276 | 15,210 | 2,377,110 | 28,992 | 41,103 |
| 1901. | 4,260,747 | 2,388,823 | 612,362 | 1,175,454 | 20,644 | 21,000 | 2,443,062 | 22,304 | 33,286 |
| 1902. | 5,003,782 | 2,405,000 | 639,600 | 1,245,800 | 22,634 | 19,000 | 4,796,807 | 12,536 | 34,504 |
| 1903. | 6,219,541 | 2,840,517 | 598,910 | 1,305,709 | 23,080 | 23,258 | 4,727,543 | 11,583 | 35,031 |
| 1904. | 7,022,841 | 2,999,787 | 554,632 | 1,482,708 | 14,173 | 18,800 | 4,583,522 | 11,254 | 37,409 |
| 1905. | 7,395,409 | 3,077,000 | 670,000 | 1,442,000 | 12,118 | 24,100 | 3,694,725 | 6,751 | 33,468 |
| 1906. | 8,481,423 | 3,314,100 | 747,900 | 1,683,500 | 11,795 | 25,614 | 3,869,772 | 11,189 | 32,407 |
| 1907. | 10,008,000 | 3,590,000 | 579,900 | 1,860,000 | 18,000 | 24,800 | 2,438,409 | 18,200 | 30,480 |
| 1908. | 10,057,145 | 3,400,700 | 560,200 | 1,851,900 | 13,403 | 26,112 | 2,535,833 | 15,865 | 30,522 |
| 1909. | 11,890,000 | 3,573,848 | 558,000 | 2,040,364 | 13,794 | 26,927 | 2,211,653 | 9,378 | 30,503 |
| 1910. | 14,605,542 | 4,038,000 | 526,000 | 2,324,000 | 14,536 | 20,226 | 2,110,540 | 7,925 | 32,461 |
| 1911. | 16,639,000 | 4,470,100 | 518,000 | 3,812,635 | 14,098 | 23,635 | 3,291,000 | 6,036 | 34,255 |
| 1912. | ..... | 4,949,126 | ..... | 4,403,688 | ..... | ..... | ..... | ..... | ..... |

| Year. | Mineral Paints (Ochers). | Nickel. | Phosphate Rock. | Pyrites. | Salt. | Silver. *Kg.* | Sulphur. Ore. (*g*) | Zinc. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Ore. | Metal. |
| 1899.... | 32,750 | 1,740 | 645,868 | 318,832 | 1,193,532 | ..... | 11,744 | 84,813 | 39,274 |
| 1900.... | 33,080 | 1,700 | 587,919 | 305,073 | 1,088,634 | ..... | 11,551 | 67,059 | 36,305 |
| 1901.... | 35,704 | 1,800 | 535,676 | 307,447 | 910,000 | ..... | 7,000 | 61,539 | 37,600 |
| 1902.... | 34,770 | 1,600 | 543,900 | 318,235 | 863,927 | ..... | 8,021 | 57,982 | 36,300 |
| 1903.... | 34,042 | 1,500 | 475,783 | 322,118 | 967,531 | ..... | 7,375 | 66,922 | 37,416 |
| 1904.... | 34,945 | 1,500 | 423,521 | 271,544 | 1,153,754 | ..... | 5,447 | 52,842 | 41,600 |
| 1905.... | 37,800 | 1,800 | 476,720 | 267,114 | 1,162,100 | ..... | 4,637 | 62,150 | 43,200 |
| 1906.... | 35,550 | 1,750 | 469,408 | 265,261 | 1,388,500 | 50,058 | 2,713 | 53,466 | 46,536 |
| 1907.... | 32,856 | 1,500 | 432,237 | 283,000 | 1,324,000 | 47,009 | 2,000 | 44,000 | 47,900 |
| 1908.... | 33,060 | 1,800 | 485,607 | 284,717 | 1,173,000 | 61,184 | 2,189 | 52,611 | 47,880 |
| 1909.... | 33,540 | 1,600 | 397,908 | 273,221 | 1,113,000 | 63,671 | 2,900 | 96,903 | 49,956 |
| 1910.... | 32,870 | 2,100 | 333,506 | 250,432 | 1,051,427 | 52,957 | 2,641 | 50,624 | 52,598 |
| 1911.... | 34,542 | 1,180 | 312,204 | 277,900 | 1,339,000 | 47,277 | 1,200 | 43,761 | 57,110 |
| 1912.... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

(*a*) From *Statistique de l'Industrie Minérale.* (*b*) Not reported. (*c*) Includes pure bitumen, bituminous schist and sand, and asphaltic limestone. (*d*) Argentiferous lead ore. (*e*) Lead produced from native ores only. (*g*) Sulphur and limestone impregnated with sulphur. (*h*) From ores.

## MINERAL PRODUCTION OF ALGERIA. (*a*)

(In metric tons.)

| Year. | Anti-mony Ore. | Copper Ore. | Gypsum. | | Iron Ore. | Lead-Silver. Ore. | Mer-cury. | Onyx. | Phos-phate Rock. | Salt. | Zinc Ore. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Crude. | Plaster. | | | | | | | |
| 1899... | 200 | 472 | 200 | 31,800 | 550,921 | 389 | ..... | 217 | 324,983 | 17,378 | 42,970 |
| 1900... | 93 | ..... | 500 | 37,100 | 174,000 | 222 | ..... | 228 | 319,422 | 18,325 | 30,281 |
| 1901... | .... | 7,267 | 600 | 34,740 | 161,303 | 1,614 | ..... | 294 | 265,000 | 18,518 | 26,913 |
| 1902... | 39 | 1,955 | 600 | 35,500 | 525,012 | 26 | ..... | 150 | 305,174 | 27,263 | 33,139 |
| 1903... | 490 | 100 | 300 | 33,000 | 588,893 | 499 | ..... | 67 | 320,834 | 26,329 | 43,313 |
| 1904... | 160 | 1,804 | 350 | 38,420 | 468,737 | 511 | ..... | 121 | 343,317 | 18,563 | 47,192 |
| 1905... | ..... | 1,784 | ..... | 34,743 | 568,609 | 7,470 | ..... | 270 | 334,784 | 26,986 | 67,922 |
| 1906... | 50 | 2,786 | ..... | 27,950 | 779,826 | 11,246 | ..... | 216 | 333,531 | 22,615 | 74,351 |
| 1907... | 799 | 16,259 | ..... | 26,400 | 973,445 | 15,264 | 590 | 328 | 373,763 | 20,390 | 71,046 |
| 1908... | 190 | 3,330 | ..... | 25,500 | 943,424 | 10,626 | 1,556 | 300 | 452,060 | 25,215 | 94,398 |
| 1909... | 163 | 67 | ..... | 29,000 | 836,044 | 11,131 | ..... | 200 | 345,385 | 17,817 | 81,852 |
| 1910 (a) | (*c*)4475 | 112 | ..... | 48,500 | 1,064,909 | 12,652 | 50 | 123 | 412,319 | 21,470 | 94,445 |
| 1911... | (*c*)7428 | 137 | ..... | 51,760 | 1,073,965 | 14,312 | ..... | 198 | 739,000 | 20,431 | 80,429 |
| 1912... | (*c*)2165 | 60 | ..... | ..... | 1,238,644 | 24,516 | ..... | 300 | 700,745 | 23,950 | 100,000 |

## MINERAL PRODUCTION OF NEW CALEDONIA. (*a*)

(In metric tons.)

| Year. | Chrome Iron. Ore. | Cobalt. Ore. | Copper Ore. | Nickel. Ore. | Year. | Chrome Iron Ore. | Cobalt Ore. | Copper Ore. | Nickel Ore. |
|---|---|---|---|---|---|---|---|---|---|
| 1900..... | 10,474 | 2,438 | 2 | 100,319 | 1907... | 57,367 | 29,800 | 437 | 119,000 |
| 1901..... | 17,451 | 3,123 | 6,349 | 132,814 | 1908... | 25,371 | 2,360 | (*b*) 10 | 108,000 |
| 1902..... | 10,281 | 7,512 | 3,720 | 129,653 | 1909... | 40,000 | 548 | 9,600 | 86,000 |
| 1903..... | 21,437 | 8,292 | 10 | 77,360 | 1910... | 40,000 | 54 | 8,000 | 99,000 |
| 1904..... | 42,197 | 8,964 | *Nil.* | 98,655 | 1911... | 35,000 | *Nil.* | 1,900 | 142,000 |
| 1905..... | 51,374 | 7,920 | *Nil.* | 125,289 | 1912(*c*). | 51,516 | *Nil.* | (*d*) | ..... |
| 1906 .... | 84,211 | 2,600 | 207 | 118,890 | | | | | |

(*a*) From *Statistique de l'Industrie Minérale.* (*b*) From *Le Bulletin du Commerce* Nouméa. (*c*) Exports *Echo des Mines.* (*d*) Copper matte worth $101,000.

MINERAL PRODUCTION OF TUNIS. (*a*)

(In metric tons.)

| Year. | Salt. | Lead Ore. | Phosphate of Lime. | Zinc Ore. | Year. | Salt. | Lead Ore. | Phosphate of Lime. | Zinc Ore. |
|---|---|---|---|---|---|---|---|---|---|
| 1900.... | 9,160 | 6,864 | 178,000 | 16,596 | 1906... | 62,600 | 14,800 | 796,000 | 32,400 |
| 1901.... | 16,900 | 8,158 | 172,000 | 17,879 | 1907... | 78,200 | 18,600 | 1,069,000 | 22,800 |
| 1902.... | 12,600 | 12,892 | 264,930 | 18,400 | 1908... | 149,600 | 37,500 | 1,300,500 | 26,500 |
| 1903.... | 18,846 | 12,752 | 352,088 | 21,262 | 1909... | 118,400 | 41,600 | 1,300,000 | 24,500 |
| 1904.... | 23,600 | 16,800 | 455,197 | 27,200 | 1910... | 199,700 | (*c*) 37,000 | 1,334,000 | (*c*) 32,500 |
| 1905.... | 54,900 | 15,200 | 522,000 | 37,100 | 1911... | 63,700 | 36,100 | 1,592,000 | (*c*) 27,900 |

(*a*) From *Statistique de l'Industrie Minérale.* (*b*) Not reported. (*c*) From *l'Echo des Mines.*

MINERAL IMPORTS OF FRANCE. (*a*) (*k*)

(In metric tons or dollars. 5 f = $1.)

| Year. | Alum. | Bitumen. (*f*) | Borax. | Bromides. | Cement. | Coal and coke. | Copper. | | Copper. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Ore. | Ingot and Mfres. | Sulphate. | Oxide. |
| 1897.... | 54 | 29,931 | 264 | 18 | 15,141 | 10,457,255 | 11,960 | 54,460 | 30,132 | 29 |
| 1898.... | 27 | 20,385 | 139 | 30 | 11,290 | 10,445,090 | 8,779 | 52,976 | 30,897 | 52 |
| 1899.... | 34 | 30,770 | 123 | 46 | 13,640 | 11,896,030 | 8,517 | 58,419 | 21,733 | 36 |
| 1900.... | 23 | 39,598 | 111 | 10 | 13,612 | 14,601,981 | 9,766 | 61,638 | 22,820 | 84 |
| 1901.... | 39 | 28,888 | 128 | 3 | 16,232 | 13,925,623 | 13,383 | 47,035 | 15,313 | 162 |
| 1902.... | 36 | 26,053 | 141 | 3 | 15,720 | 13,137,720 | 17,862 | 54,484 | 22,273 | 111 |
| 1903.... | 138 | 27,573 | 312 | 9 | 21,152 | 14,029,687 | 9,796 | 59,126 | 25,428 | 129 |
| 1904.... | 370 | 17,178 | 3,113 | 17 | 21,702 | 13,936,475 | 9,942 | 69,183 | 30,856 | 142 |
| 1905.... | 63 | 24,606 | 1,736 | 31 | 21,954 | 13,910,523 | 14,252 | 70,101 | 23,805 | 57 |
| 1906.... | 105 | 99,336 | 189 | 93 | 24,974 | 17,848,284 | 11,932 | 64,590 | 15,358 | 97 |
| 1907.... | ..... | 31,700 | ..... | ..... | 24,839 | 18,706,000 | 12,063 | 76,282 | ..... | ..... |
| 1908.... | ..... | 48,000 | ..... | ..... | 31,550 | 18,563,000 | 15,300 | 86,985 | ..... | ..... |
| 1909.... | ..... | 54,000 | ..... | ..... | 46,664 | 19,387,000 | 27,400 | 86,143 | ..... | ..... |
| 1910.... | 46 | 36,360 | 8,322 | 17 | 51,905 | 18,145,872 | 23,362 | 93,548 | 11,887 | 427 |
| 1911.... | 129 | 32,207 | 3,128 | 12 | 86,457 | 19,740,539 | 24,585 | 104,724 | 17,759 | 151 |
| 1912.... | 190 | 39,508 | 3,277 | 20 | 115,286 | 19,878,477 | 19,671 | 112,148 | 16,800 | 134 |

| Year. | Cobalt Ore. | Iron. | | | | | Kaolin. | Lead. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Ore. | Pig. | Iron and Steel, Mfres. of. | Sulphate. | Oxide. | | Ore. | Carbonate. | Pig, Scrap and Mfres. |
| 1897.... | ..... | 2,137,860 | 35,633 | 60,804 | 1,353 | 1,125 | 42,384 | 13,981 | 1,327 | 86,589 |
| 1898.... | ..... | 2,032,240 | (*b*) | 47,325 | 896 | 1,021 | 40,352 | 14,377 | 1,376 | 74,902 |
| 1899.... | ..... | 1,950,665 | (*b*) | 64,178 | 1,698 | 1,037 | 36,904 | 12,637 | 2,029 | 67,149 |
| 1900.... | ..... | 2,119,003 | 149,755 | 118,152 | 1,589 | 1,022 | 39,842 | 19,772 | 1,739 | 70,857 |
| 1901.... | ..... | 1,662,875 | 61,085 | 77,742 | 45 | 1,001 | 41,972 | 15,430 | 1,789 | 59,051 |
| 1902.... | ..... | 1,563,334 | 38,521 | 60,697 | 17 | 1,051 | 41,165 | 13,121 | 2,223 | 58,694 |
| 1903.... | ..... | 1,832,820 | 121,726 | 119,799 | 36 | 1,207 | 47,534 | 20,172 | 2,040 | 75,416 |
| 1904.... | ..... | 1,738,514 | 135,252 | 125,709 | 319 | 1,151 | 50,465 | 25,731 | 2,221 | 76,198 |
| 1905.... | ..... | 2,151,954 | 122,102 | 150,480 | 709 | 1,330 | 52,603 | 35,103 | 2,306 | 73,938 |
| 1906.... | ..... | 2,015,550 | 156,618 | 342,411 | 132 | 1,311 | 44,772 | 43,137 | 2,072 | 67,651 |
| 1907.... | 1,396 | 1,999,000 | 154,031 | 336,337 | ..... | ..... | 53,447 | 42,342 | ..... | 53,359 |
| 1908.... | 1,500 | 1,454,000 | 168,810 | 373,624 | ..... | ..... | 58,909 | 40,700 | ..... | 70,824 |
| 1909.... | 400 | 1,202,619 | 194,225 | 354,428 | ..... | ..... | 59,490 | 38,400 | ..... | 68,332 |
| 1910.... | 2.6 | 1,318,520 | 36,637 | 378,227 | 2,243 | 1,235 | 62,920 | 28,950 | 3,259 | 64,517 |
| 1911.... | 0.3 | 1,350,794 | 49,612 | 77,000 | 4,454 | 1,511 | 66,500 | 47,340 | 3,095 | 69,791 |
| 1912.... | ..... | 1,454,190 | 57,241 | 114,100 | 2,800 | 1,466 | 63,783 | 42,499 | 2,919 | 65,449 |

| Year. | Lime, Chloride of. | Manganese Ore. | Nickel. | | Petroleum. | Phosphate Rock. | Platinum Kg. | Potassium. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Ore. | Metal. | | | | Chloride. | Chromate. (h) |
| 1897 .... | 1,713 | 85,500 | 17,441 | 316 | 288,671 | 313,608 | 1,069 | 11,630 | 2,852 |
| 1898 .... | 1,288 | 100,243 | 24,935 | 330 | 291,961 | 336,842 | 505 | 10,929 | 2,890 |
| 1899 .... | 1,887 | 106,630 | 28,620 | 286 | 306,078 | 242,021 | 817 | 13,335 | 3,147 |
| 1900 .... | 1,215 | 120,790 | 17,687 | 299 | 302,482 | 283,921 | 2,398 | 13,524 | 3,293 |
| 1901 .... | 1,400 | 94,365 | 39,497 | 252 | 225,962 | 275,285 | 1,857 | 13,299 | 2,784 |
| 1902 .... | 2,130 | 85,629 | 58,374 | 301 | 148,170 | 302,898 | 2,940 | 10,802 | 2,861 |
| 1903 .... | 919 | 109,930 | 13,933 | 427 | (g)476,230 | 343,012 | 3,764 | 12,275 | 2,760 |
| 1904 .... | 1,679 | 105,652 | 20,698 | 313 | (g)435,730 | 419,720 | 5,650 | 14,734 | 2,618 |
| 1905 .... | 406 | 140,871 | 49,698 | 632 | (g)512,727 | 447,738 | 4,023 | 21,819 | 2,619 |
| 1906 .... | 593 | 127,235 | 44,960 | 480 | (g)213,462 | 533,213 | 5,708 | 26,523 | 3,024 |
| 1907 .... | ..... | 192,448 | 45,892 | 979 | (g)311,000 | 636,549 | 4,373 | ..... | ..... |
| 1908(k).. | ..... | 170,500 | 42,200 | 1,281 | (g)300,000 | 767,424 | 3,955 | ..... | ..... |
| 1909(k).. | ..... | 177,314 | 12,200 | ..... | (g)300,000 | 645,178 | 5,914 | ..... | ..... |
| 1910 .... | 333 | 188,292 | 28,001 | 2,074 | (g)271,500 | 687,675 | 7,795 | 34,974 | 3,009 |
| 1911 .... | 53 | 235,400 | 43,014 | 6,465 | (g)375,000 | 740,375 | 9,392 | 39,508 | 2,991 |
| 1912 .... | 24 | 225,379 | 27,126 | 5,032 | (g)360,000 | 903,490 | 6,236 | 45,174 | 3,178 |

| Year. | Potassium (Cont'd). | | Pyrites. | Quicksilver. | | Sal-ammoniac. | Salt. | Sodium. | |
|---|---|---|---|---|---|---|---|---|---|
| | Nitrate. | Carbonate | | Ore. | Metal. | | | Hydrate. | Nitrate. |
| 1898 .... | 1,008 | 2,418 | 71,569 | 19 | 221 | 20,426 | 35,863 | 1,772 | 8,026,400 |
| 1899 .... | 1,015 | 2,779 | 109,696 | 21 | 276 | 12,210 | 37,970 | 1,494 | 9,341,600 |
| 1900 .... | 1,928 | 2,768 | 156,825 | 22 | 161 | 15,205 | 32,045 | 1,062 | 11,995,820 |
| 1901 .... | 757 | 2,520 | 205,617 | 23 | 205 | 9,268 | 32,347 | 869 | 10,526,400 |
| 1902 .... | 1,547 | 1,539 | 170,783 | 24 | 224 | 15,446 | 32,505 | 643 | 9,372,600 |
| 1903 .... | 1,530 | 3,019 | 205,322 | 20 | 220 | 12,462 | 48,556 | 781 | 10,810,775 |
| 1904 .... | 2,117 | 3,781 | 230,097 | 22 | 208 | 13,744 | 46,232 | 1,068 | 9,074,859 |
| 1905 .... | 1,022 | 3,542 | 271,684 | ..... | 228 | 11,639 | 45,241 | 860 | 11,336,752 |
| 1906 .... | 684 | 2,206 | 349,514 | ..... | 242 | 18,146 | 38,361 | 614 | 13,678,848 |
| 1907 .... | ..... | ..... | 355,300 | ..... | 216 | ..... | 30,000 | ..... | ..... |
| 1908(k) . | ..... | ..... | 348,300 | ..... | 180 | ..... | 33,000 | ..... | ..... |
| 1909(k) . | ..... | ..... | 275,600 | ..... | 191 | ..... | 30,000 | ..... | ..... |
| 1910 .... | 132 | 2,579 | 309,400 | ..... | 146 | 27,860 | 49,800 | 577 | 345,160 |
| 1911 .... | 174 | 4,452 | 318,530 | ..... | 196 | 23,200 | 47,200 | 550 | 317,725 |
| 1912 .... | 53 | 4,017 | 404,982 | ..... | 213 | 25,056 | 39,500 | 556 | 354,776 |

| Year. | Sulphur. | Sulphuric Acid. | Superphosphate of Lime. | Tin. | | Zinc. | |
|---|---|---|---|---|---|---|---|
| | | | | Ore. | Metal. | Ore. | Metal. |
| 1898..... | 130,289 | 4,666 | 178,569 | 357 | 9,247 | 60,481 | 32,342 |
| 1899..... | 120,062 | 4,583 | 171,631 | 486 | 6,907 | 78,192 | 25,516 |
| 1900..... | 133,531 | 4,254 | 143,437 | 512 | 7,324 | 66,178 | 33,144 |
| 1901..... | 101,301 | 5,386 | 165,361 | 365 | 7,314 | 74,553 | 29,812 |
| 1902..... | 85,839 | 7,793 | 116,093 | 748 | 8,575 | 69,451 | 36,564 |
| 1903..... | 109,594 | 13,241 | 89,229 | 1,808 | 9,873 | 67,258 | 39,305 |
| 1904..... | 148,547 | 11,212 | 72,921 | 1,344 | 9,352 | 88,083 | 35,737 |
| 1905..... | 129,877 | 10,915 | 31,729 | 1,362 | 9,898 | 105,069 | 29,163 |
| 1906..... | 131,678 | 5,268 | 44,502 | 1,038 | 7,687 | 106,307 | 26,960 |
| 1907..... | 106,050 | ..... | ..... | 961 | 7,693 | 114,699 | 33,503 |
| 1908(k)..... | 195,000 | ..... | ..... | 1,000 | 8,482 | 137,900 | 40,312 |
| 1909(k)..... | 196,300 | ..... | ..... | 1,900 | 9,683 | 120,600 | 32,749 |
| 1910..... | 202,263 | 14,642 | 132,530 | 1,651 | 8,517 | 193,360 | 19,237 |
| 1911..... | 267,969 | 15,150 | 79,385 | 2,544 | 8,456 | 160,180 | 42,785 |
| 1912..... | 253,363 | 13,169 | 89,059 | 1,726 | 8,503 | 158,429 | 43,795 |

MINERAL AND METALLURGICAL EXPORTS OF FRANCE. (*a*) (*k*)
(In metric tons.)

| Year. | Aluminum. | Antimony. | | Arsenic. | Cement. | Coal. | Copper. | | Gold. *Kg.* (*d*) |
|---|---|---|---|---|---|---|---|---|---|
| | | Ore. | Metal. | | | | Ore. (*c*) | Metal. | |
| 1897.... | 224 | 623 | 61 | ..... | 244,504 | 1,142,195 | 2,000 | 12,667 | 3,335 |
| 1898.... | 192 | 616 | 101 | ..... | 241,150 | 1,320,616 | 1,783 | 14,350 | 1,812 |
| 1899.... | 256 | 304 | 255 | ..... | 244,480 | 1,229,090 | 2,078 | 17,949 | 2,622 |
| 1900.... | 324 | 154 | 336 | ..... | 232,577 | 1,201,210 | 9,197 | 16,791 | 883 |
| 1901.... | 307 | 645 | 741 | ..... | 242,010 | 908,583 | 16,066 | 14,776 | 1,869 |
| 1902.... | 748 | 595 | 666 | ..... | 210,590 | 910,760 | 20,489 | 14,423 | 1,517 |
| 1903.... | 666 | 904 | 1,358 | ..... | 233,835 | 2,238,735 | 12,487 | 11,403 | 3,139 |
| 1904.... | 664 | 1,191 | 720 | ..... | 260,686 | 2,384,928 | 14,258 | 12,663 | 1,537 |
| 1905.... | 928 | 981 | 815 | ..... | 275,503 | (*i*)3,348,010 | 13,260 | 13,800 | 5,740 |
| 1906.... | 1,522 | 3,541 | 871 | ..... | 329,879 | (*i*)1,448,000 | 8,056 | 6,130 | 11,727 |
| 1907.... | 1,118 | 3,460 | 1,270 | ..... | 366,624 | (*i*)1,224,000 | 4,151 | 18,630 | 6,289 |
| 1908.... | 1,332 | 3,300 | 2,129 | 8,600 | 342,131 | (*i*)1,117,000 | 3,600 | 17,845 | 4,455 |
| 1909.... | 4,425 | 4,000 | 2,408 | 3,267 | 316,486 | (*i*)1,493,308 | 6,200 | 18,775 | 5,366 |
| 1910.... | 4,148 | 4,583 | 2,163 | 2,411 | 315,020 | (*i*)1,580,077 | 4,163 | 20,884 | 7,264 |
| 1911.... | 4,058 | 3,991 | 1,945 | 832 | 333,043 | (*i*)1,635,000 | 8,335 | 22,690 | ..... |
| 1912.... | 6,605 | 1,673 | 2,890 | 1,497 | 361,425 | (*i*)2,320,349 | 6,374 | 42,307 | 775 |

| Year. | Iron. | | | | Lead. | | Manganese Ore. |
|---|---|---|---|---|---|---|---|
| | Ore. | Pig. | Bars. | Steel. | Ore. | Metal. | |
| 1897..... | 299,589 | 108,645 | 39,894 | 45,809 | 12,007 | 10,364 | 19,464 |
| 1898..... | 236,169 | 162,991 | 27,424 | 47,278 | 10,216 | 3,663 | 12,229 |
| 1899..... | 291,346 | 153,792 | 29,112 | 33,584 | 3,909 | 1,163 | 12,289 |
| 1900..... | 371,799 | 114,361 | 18,763 | 19,535 | 2,345 | 958 | 8,392 |
| 1901..... | 258,925 | 96,463 | 25,220 | 56,347 | 3,490 | 718 | 5,289 |
| 1902..... | 422,677 | 213,081 | 23,828 | 121,932 | 2,414 | 648 | 1,948 |
| 1903..... | 714,173 | 196,444 | 40,533 | 215,737 | 2,313 | 13,048 | 717 |
| 1904..... | 1,219,149 | 191,819 | 40,374 | 246,738 | 1,860 | 13,467 | 1,392 |
| 1905..... | 1,355,932 | 218,227 | 67,240 | 343,612 | 3,064 | 12,903 | 662 |
| 1906..... | 1,759,443 | 143,142 | 58,826 | 236,617 | 1,354 | 997 | 4,103 |
| 1907..... | 2,147,000 | 249,708 | 84,557 | 291,434 | 1,210 | 1,912 | 5,167 |
| 1908..... | 2,384,000 | 171,797 | 86,691 | 360,509 | 6,700 | 1,974 | 1,000 |
| 1909..... | 3,907,338 | 161,058 | 96,999 | 318,925 | 2,800 | 2,458 | 1,149 |
| 1910..... | 4,892,542 | 110,086 | 122,543 | (*k*)302,168 | 5,855 | 3,004 | 722 |
| 1911..... | 6,160,100 | 104,350 | 171,000 | 100,000 | 9,691 | 2,660 | 902 |
| 1912..... | 8,318,312 | 216,895 | 67,000 | 170,000 | 12,276 | 1,660 | 2,282 |

| Year. | Nickel, Refined. | Phosphate Rock. | Plaster. | Pyrites. | Silver. *Kg.* (*e*) | Tin (Metal). | Zinc. | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Ore. | Spelter, Sheets and Scrap. |
| 1898..... | 526 | 93,742 | 106,790 | 60,406 | 1,886 | 587 | 60,664 | 16,995 |
| 1899..... | 280 | 70,517 | 112,520 | 53,395 | ..... | 666 | 76,104 | 14,958 |
| 1900..... | 599 | 89,135 | 108,387 | 64,530 | 15,470 | 716 | 54,663 | 12,712 |
| 1901..... | 1,031 | 81,405 | 101,063 | 52,952 | 16,745 | 438 | 42,995 | 15,022 |
| 1902..... | 397 | 62,375 | 110,270 | 63,920 | 17,184 | 654 | 47,724 | 16,158 |
| 1903..... | 720 | 72,252 | 131,245 | 119,173 | 43,690 | 1,994 | 62,731 | 12,657 |
| 1904..... | 906 | 78,612 | 139,551 | 40,833 | 23,105 | 2,300 | 57,780 | 19,063 |
| 1905..... | 1,583 | 55,240 | 124,561 | 21,257 | 66,904 | 2,611 | 72,512 | 17,802 |
| 1906..... | 1,088 | 81,660 | 142,339 | 26,216 | 87,952 | 601 | 67,258 | 19,607 |
| 1907..... | 1,414 | 100,508 | 137,356 | 24,417 | 58,199 | 729 | 54,316 | 21,928 |
| 1908..... | 1,230 | 71,509 | 132,924 | 40,300 | 56,957 | 810 | 57,800 | 20,589 |
| 1909..... | 1,940 | 47,611 | 120,701 | 40,200 | 56,549 | 886 | 60,000 | 24,729 |
| 1910..... | 2,050 | 44,384 | 152,390 | 56,735 | 58,294 | 1,224 | 56,800 | 22,975 |
| 1911..... | 880 | 31,413 | 148,952 | 68,919 | 17,256 | 1,520 | 51,737 | 25,500 |
| 1912..... | 1,192 | 22,062 | 174,486 | 43,905 | 3,856 | 1,450 | 60,000 | 34,124 |

(*a*) From *L'Economiste Francais* (representing the *Commerce Spécial*) except for 1903-06, inclusive, which are from *Tableau Général du Commerce et de la Navigation*. (*b*) Not reported. (*c*) Includes matte. (*d*) Gold and platinum in sheets, leaves, threads or jewelry and crude platinum. (*e*) Silver in sheets, leaves, wire and jewelry. (*f*) Includes bitumen, bituminous schist and sand and asphaltic limestone. (*g*) Crude and refined. Transposition from hectoliters to tons was performed by assuming specific gravity of petroleum to be 0.9. (*h*) Includes chromate of soda. (*i*) Includes coke. (*k*) From *Statistique de l'Industrie Minérale* in the years 1908, 1909, 1910. Steel in 1910 not classified as before. 1911, from *l'Echo des Mines et Metallurgie*.

# GERMANY

**The mineral production and foreign commerce of the German Empire are given in the following tables in metric tons unless otherwise specified, or in dollars, on the basis of four marks to the dollar.**

MINERAL PRODUCTION OF GERMANY. (a)

| Year. | Alum. | Aluminum. Sulphate | Arsenic. | | Asphaltum. | Boracite. | Cadmium. Kg. | Coal. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Ore. | Salts. | | | | Bituminous. | Lignitic. |
| 1898 .... | 4,069 | 35,366 | 3,527 | 2,679 | 67,649 | 230 | 14,943 | 96,309,652 | 31,648,898 |
| 1899 .... | 3,358 | 37,693 | 3,834 | 2,423 | 74,770 | 183 | 13,608 | 101,639,753 | 34,204,666 |
| 1900 .... | 4,355 | 44,372 | 4,379 | 2,415 | 89,685 | 232 | 13,553 | 109,290,237 | 40,498,019 |
| 1901 .... | 4,145 | 46,807 | 4,035 | 2,549 | 90,193 | 184 | 13,144 | 108,539,444 | 44,479,970 |
| 1902 .... | 4,108 | 47,905 | 3,959 | 2,828 | 88,374 | 196 | 12,625 | 107,473,933 | 43,126,281 |
| 1903 .... | 3,934 | 49,727 | 4,369 | 2,768 | 87,454 | 159 | 16,565 | 116,637,765 | 45,819,488 |
| 1904 .... | 3,850 | 55,881 | 4,390 | 2,829 | 91,736 | 135 | 25,245 | 120,815,503 | 48,635,080 |
| 1905 .... | 4,127 | 52,892 | 4,913 | 2,535 | 103,006 | 183 | 24,568 | 121,298,607 | 52,512,062 |
| 1906 .... | 4,494 | 55,969 | 6,249 | 3,052 | 117,413 | 161 | 21,486 | 137,117,926 | 56,419,567 |
| 1907 .... | 4,200 | 59,473 | 4,878 | 2,904 | 126,649 | 114 | 32,949 | 143,185,691 | 62,546,671 |
| 1908 .... | 3,802 | 53,958 | 6,065 | 2,822 | 89,009 | 128 | 32,995 | 147,671,149 | 67,615,200 |
| 1909 .... | 4,179 | 56,096 | 6,150 | 2,911 | 77,537 | 149 | 37,187 | 148,788,050 | 68,657,606 |
| 1910 .... | 4,406 | 58,349 | 6,151 | 3,066 | 81,208 | 167 | 41,100 | 152,827,777 | 69,473,883 |
| 1911 .... | 3,076 | ..... | 4,859 | 2,981 | 81,902 | 160 | 42,000 | 160,747,580 | 73,760,867 |

| Year. | Cobalt, Nickel and Bismuth Ores. | Copper. | | | | Gold. | Graphite. |
|---|---|---|---|---|---|---|---|
| | | Ore. | Matte. (b) | Ingots. | Sulphate. | | |
| 1898 ..... | 3,157 | 702,781 | 62 | 30,695 | 4,352 | $1,891,974 | 4,593 |
| 1899 ..... | 1,270 | 733,619 | 95 | 34,634 | 5,142 | 1,731,153 | 5,196 |
| 1900 ..... | 4,495 | 747,749 | 4,207 | 30,929 | 5,076 | 2,030,200 | 9,248 |
| 1901 ..... | 10,479 | 777,339 | 365 | 31,317 | 5,192 | 1,830,835 | 4,435 |
| 1902 ..... | 12,433 | 761,921 | 447 | 30,578 | 4,997 | 1,770,361 | 5,023 |
| 1903 ..... | 14,607 | 772,695 | 583 | 31,214 | 5,200 | 1,709,223 | 3,720 |
| 1904 ..... | 14,016 | 798,214 | 641 | 30,264 | 6,584 | 1,819,538 | 3,784 |
| 1905 ..... | 10,848 | 793,488 | 1,635 | 31,713 | 6,988 | 2,611,812 | 4,921 |
| 1906 ..... | ..... | 768,523 | 771 | 32,275 | 6,757 | 2,931,750 | 4,055 |
| 1907 ..... | 2,809 | 771,227 | 527 | 31,946 | 5,284 | 3,111,379 | 4,033 |
| 1908 ..... | 8,535 | 727,384 | 328 | 30,001 | 7,117 | 3,162,544 | 4,844 |
| 1909 ..... | 10,388 | 798,618 | 2,242 | 31,126 | 6,211 | 3,366,986 | 6,774 |
| 1910 ..... | 10,313 | 925,957 | 3,735 | 34,926 | 5,210 | 3,227,250 | 7,415 |
| 1911 ..... | ..... | 868,600 | 1,142 | 37,452 | 7,353 | 3,302,300 | 11,298 |

| Year. | Iron and Steel. | | | | Lead. | | |
|---|---|---|---|---|---|---|---|
| | Iron Ore. | Pig Iron. (c) | Wrought iron and Steel. | Sulphate. (d) | Ore. | Pig. | Litharge. |
| 1898 .... | 15,901,263 | 7,312,766 | 6,941,278 | 10,422 | 149,311 | 132,742 | 3,857 |
| 1899 .... | 17,989,635 | 8,153,133 | 7,532,524 | 10,931 | 144,370 | 129,225 | 3,562 |
| 1900 .... | 18,964,294 | 8,520,540 | 7,377,275 | 10,913 | 148,257 | 121,513 | 3,088 |
| 1901 .... | 16,570,182 | 7,880,087 | 7,033,438 | 11,148 | 153,341 | 123,098 | 4,101 |
| 1902 .... | 17,963,591 | 8,529,900 | 8,317,231 | ..... | 167,855 | 140,331 | 4,197 |
| 1903 .... | 21,230,650 | 10,017,901 | 9,226,898 | 12,243 | 165,991 | 145,319 | 4,428 |
| 1904 .... | 22,047,393 | 10,058,273 | 9,239,302 | 13,585 | 164,440 | 137,580 | 4,332 |
| 1905 .... | 23,444,073 | 10,875,061 | 10,309,690 | 12,949 | 152,725 | 152,590 | 3,786 |
| 1906 .... | 26,734,570 | 12,292,819 | 11,307,807 | 13,376 | 140,914 | 150,741 | 4,137 |
| 1907 .... | 27,697,127 | 12,875,159 | 12,063,632 | 14,033 | 147,272 | 142,271 | 4,325 |
| 1908 .... | 24,278,151 | 11,805,321 | 10,930,933 | 15,738 | 156,861 | 164,079 | 5,339 |
| 1909 .... | 25,505,409 | 12,917,653 | 11,719,239 | 21,838 | 159,852 | 167,920 | 3,059 |
| 1910 .... | 28,709,700 | 14,502,183 | 12,988,177 | 18,677 | 148,497 | 159,851 | 3,581 |
| 1911 .... | 29,879,361 | 15,280,527 | 14,384,271 | 17,002 | 140,154 | 161,287 | 3,687 |

| Year. | Magnesium Salts. | | Manganese Ore. | Petroleum. | Potassium Salts. | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Chloride. | Sulphate. | | | Chloride. | Kainite. (f) | Sulphate. | Potassium-Magnesium Sulphate. | Other than Kainite. |
| 1898 ... | 19,819 | 30,295 | 43,354 | 25,989 | 191,347 | 1,103,643 | 18,853 | 13,982 | 1,105,212 |
| 1899 ... | 21,370 | 39,540 | 61,329 | 27,027 | 207,506 | 1,108,159 | 26,103 | 9,765 | 1,384,972 |
| 1900 ... | 19,397 | 48,591 | 59,204 | 50,375 | 271,512 | 1,227,873 | 30,853 | 15,368 | 1,822,758 |
| 1901 ... | 21,018 | 46,714 | 56,691 | 44,095 | 294,666 | 1,498,569 | 37,394 | 15,612 | 2,036,325 |
| 1902 ... | 19,658 | 39,262 | 49,812 | 49,725 | 267,512 | 1,322,623 | 28,278 | 18,147 | 1,962,384 |
| 1903 ... | 22,990 | 37,844 | 47,994 | 62,680 | 280,248 | 1,557,243 | 36,674 | 23,631 | 2,073,720 |
| 1904 ... | 25,730 | 39,412 | 52,886 | 89,620 | 297,238 | 1,905,893 | 43,959 | 29,285 | 2,179,471 |
| 1905 ... | 29,017 | 58,568 | 51,463 | 78,869 | 373,177 | 2,387,643 | 47,994 | 34,222 | 2,655,845 |
| 1906 ... | 38,468 | 43,041 | 52,485 | 81,350 | 403,387 | 2,720,594 | 54,490 | 35,211 | 2,821,073 |
| 1907 ... | 32,891 | 41,105 | 73,105 | 106,379 | 473,138 | 2,624,412 | 60,292 | 33,368 | 3,124,955 |
| 1908 ... | 29,775 | 42,977 | 67,692 | 141,900 | 511,258 | 2,715,487 | 55,756 | 33,149 | 3,383,535 |
| 1909 ... | 31,526 | 53,812 | 77,177 | 143,244 | 624,994 | 3,181,349 | 68,539 | 38,722 | 3,969,554 |
| 1910 ... | 32,207 | 57,314 | 80,560 | 145,168 | 741,259 | 4,249,667 | 84,583 | 37,438 | 4,062,004 |
| 1911 ... | 36,764 | 55,179 | 87,297 | 142,992 | 838,420 | 4,425,497 | 107,631 | 42,253 | 5,181,379 |

| Year. | Pyrites. | Salt. | | Silver and Gold Ore. | Silver. *Kg.* | Sodium Sulphate. | Sulphur. | Sulphuric Acid. |
|---|---|---|---|---|---|---|---|---|
| | | Rock. | Evaporated. | | | | | |
| 1898.... | 136,849 | 807,792 | 565,683 | 14,702 | 480,578 | 69,111 | 1,954 | 754,151 |
| 1899.... | 144,623 | 861,123 | 571,058 | 13,506 | 467,590 | 79,062 | 1,663 | 813,141 |
| 1900.... | 169,447 | 926,563 | 587,464 | 12,593 | 415,735 | 90,468 | 1,445 | 829,376 |
| 1901.... | 157,433 | 985,050 | 578,751 | 11,577 | 403,796 | 76,066 | 963 | 835,000 |
| 1902.... | 165,225 | 1,010,412 | 572,846 | 11,724 | 430,610 | 90,742 | ..... | 894,409 |
| 1903.... | 170,867 | 1,095,541 | 598,394 | 11,467 | 396,253 | 83,087 | 219 | 928,190 |
| 1904.... | 174,782 | 1,079,868 | 621,064 | 10,405 | 389,827 | 75,171 | 209 | 963,384 |
| 1905.... | 185,368 | 1,165,495 | 612,062 | 10,286 | 399,775 | 68,454 | 205 | 1,228,211 |
| 1906.... | 196,971 | 1,235,041 | 635,171 | 8,066 | 393,442 | 81,175 | 178 | 1,335,128 |
| 1907.... | 196,351 | 1,285,137 | 665,547 | 8,280 | 386,933 | 80,347 | 176 | 1,402,398 |
| 1908.... | 219.456 | 1,331,984 | 665,651 | 7,653 | 407,185 | 72,667 | 811 | 1,391,653 |
| 1909.... | 198,688 | 1,370,668 | 647,939 | 7,510 | 400,562 | 71,813 | 1,185 | 1,434,709 |
| 1910.... | 215,708 | 1,424,064 | 669,120 | 6,646 | 420,003 | 84,787 | 1,272 | 1,616,336 |
| 1911.... | 217,459 | 1,436,492 | 645,991 | 4,890 | 439,580 | 82,664 | 1,251 | 1,534,455 |

| Year. | Tin. | | | Uranium and Tungsten Ores. | Zinc. | | |
|---|---|---|---|---|---|---|---|
| | Ore. | Block. | Chloride. | | Ore. | Spelter. | Sulphate. |
| 1898 ..... | 51 | 993 | ..... | 50 | 641,706 | 154,867 | 6,104 |
| 1899 ..... | 72 | 1,481 | ..... | 50 | 664,536 | 153,155 | 7,117 |
| 1900 ..... | 80 | 2,031 | (g) 143 | 43 | 639,215 | 155,790 | 6,027 |
| 1901 ..... | 82 | 1,464 | (g) 135 | 43 | 647,496 | 166,283 | 5,552 |
| 1902 ..... | 104 | 2,779 | ..... | 31 | 702,504 | 174,927 | ..... |
| 1903 ..... | 110 | 3,065 | 1,064 | 35 | 682,853 | 182,548 | 5,994 |
| 1904 ..... | 99 | 4,216 | 816 | 23 | 715,732 | 193,058 | 6,185 |
| 1905 ..... | 123 | 5,233 | 811 | 26 | 731,271 | 198,208 | 5,896 |
| 1906 ..... | ..... | 6,597 | 987 | ..... | 704,590 | 205,691 | 6,092 |
| 1907 ..... | ..... | 5,838 | 1,812 | 3 | 698,425 | 208,195 | 5,145 |
| 1908 ..... | 111 | 6,374 | 2,266 | 42 | 706,441 | 216,490 | 5,310 |
| 1909 ..... | 124 | 8,994 | 3,247 | 98 | 723,565 | 219,766 | 5,574 |
| 1910 ..... | 125 | 11,395 | 3,391 | 95 | 718,316 | 221,395 | 6,308 |
| 1911 ..... | ..... | 12,412 | 3,749 | ..... | 699,970 | 235,776 | 6,703 |

(a) From the *Vierteljahrshefte zur Statistik des Deutschen Reichs.* Where gold is reported 1 mark = $0.238. (b) Includes black copper. (c) Includes ferromanganese and spiegeleisen. (d) Contains a small quantity of copper and iron sulphate mixed. (f) Compound of potassium chloride and magnesium sulphate. (g) Includes nickel sulphate.

MINERAL PRODUCTION OF BADEN. (a)
(In metric tons and dollars; 4 marks = $1.)

| Year. | Aluminum Sulphate. | Barytes. | Coal. | Gypsum. | Manufacturers of Iron. | | |
|---|---|---|---|---|---|---|---|
| | | | | | Cast, Foundry. | Steel. | Wrought. |
| 1898.... | 2,051 | 1,100 | 4,133 | 28,037 | 39,988 | 3,875 | 1,167 |
| 1899.... | 2,153 | 2,430 | 4,700 | 29,419 | 53,608 | 3,830 | 1,402 |
| 1900.... | 2,286 | 2,970 | 4,930 | 26,381 | 50,102 | 3,532 | 1,364 |
| 1901.... | 2,260 | 3,991 | 3,650 | 28,183 | 40,100 | 8,739 | 1,158 |
| 1902.... | 2,374 | 6,234 | 2,078 | 33,150 | 40,973 | 12,663 | 1,052 |
| 1903.... | 2,498 | 8,857 | 1,990 | 29,423 | 45,233 | 7,666 | 863 |
| 1904.... | 2,392 | 9,078 | 1,485 | 26,984 | 64,320 | 7,687 | 783 |
| 1905.... | 2,581 | 11,094 | 668 | 28,823 | 74,128 | 8,053 | 842 |
| 1906.... | 2,583 | 11,984 | 1,000 | 25,643 | 81,387 | 11,068 | 466 |
| 1907.... | 2,644 | 9,303 | 2,075 | 29,153 | 98,430 | 10,818 | 533 |
| 1908.... | 2,524 | (c) 8,554 | 2,473 | 35,217 | 83,724 | 10,430 | 602 |
| 1909.... | 2,329 | (c) 15,186 | 2,356 | 36,621 | 83,458 | 11,643 | 484 |
| 1910.... | 2,141 | (c) 13,832 | 1,650 | 41,078 | 95,795 | 12,134 | 239 |
| 1911.... | 2,554 | 15,014 | (b) | 42,408 | 107,784 | 11,909 | 244 |
| 1912.... | ..... | 15,871 | ..... | 51,778 | ..... | ..... | ..... |

| Year. | Lead Ores. | Salt. | Sulphuric Acid. | Tripoli. | Zinc Ore. |
|---|---|---|---|---|---|
| 1898..... | (b) | 31,445 | 31,365 | 6 | (b) |
| 1899..... | (b) | 31,197 | 13,660 | 12 | 357 |
| 1900..... | 67 | 32,699 | 15,938 | 9 | 3,004 |
| 1901..... | 369 | 32,835 | 17,081 | 8 | 2,870 |
| 1902..... | 450 | 32,192 | 19,265 | 11 | 2,958 |
| 1903..... | 350 | 32,383 | 19,755 | 11 | 3,171 |
| 1904..... | 265 | 32,148 | 35,517 | 12 | 5,063 |
| 1905..... | 264 | 31,393 | 40,781 | 12 | 4,046 |
| 1906..... | 246 | 31,288 | 38,655 | 15 | 1,466 |
| 1907..... | 278 | 32,078 | 42,831 | 25 | 2,198 |
| 1908..... | 329 | 33,993 | 41,455 | 13 | 2,793 |
| 1909..... | 372 | 34,040 | 42,219 | 14 | 3,253 |
| 1910..... | 419 | 32,729 | 56,069 | 7 | 3,345 |
| 1911..... | 191 | 32,118 | 47,796 | 14 | 3,067 |
| 1912..... | 428 | 32,326 | ..... | 14 | 3,730 |

(a) From the *Uebersicht der Production des Bergwerks-, Hütten-, und Salinen-Betriebes in dem Badischen Staate.* (b) Not reported. (c) Includes fluorspar.

MINERAL PRODUCTION OF BAVARIA. (a)
(In metric tons; 4 marks = $1.)

| Year. | Barytes. | Kaolin. | Coal. | Coal. (Lignite). | Copperas and Other Sulphate. | Emery. | Feldspar. | Fluor-spar. | Graphite. |
|---|---|---|---|---|---|---|---|---|---|
| 1897.. | 3,365 | 24,086 | 917,022 | 39,043 | 981 | 217 | 1,689 | 4,904 | 3,861 |
| 1898.. | 4,339 | 29,196 | 964,611 | 38,663 | 886 | 280 | 1,949 | 4,440 | 4,593 |
| 1899.. | 6,214 | 25,822 | 1,004,421 | 35,736 | 900 | 399 | 287 | 3,631 | 5,196 |
| 1900.. | 10,515 | 58,795 | 1,185,296 | 39,165 | 916 | 414 | 460 | 7,456 | 9,248 |
| 1901.. | 8,711 | 35,450 | 1,203,792 | 25,224 | 590 | 366 | 788 | 5,220 | 4,435 |
| 1902.. | 8,034 | 92,073 | 1,233,568 | 27,337 | 691 | 225 | 447 | 5,460 | 5,023 |
| 1903.. | 8,642 | 88,140 | 1,356,556 | 25,189 | 814 | 220 | 1,060 | 3,410 | 3,719 |
| 1904.. | 9,411 | 95,160 | 1,341,925 | 53,517 | 893 | 265 | 1,866 | 4,770 | 3,784 |
| 1905.. | 10,030 | 99,910 | 1,317,951 | 154,128 | 844 | 255 | 1,710 | 4,413 | 4,921 |
| 1906.. | 19,817 | 98,138 | 1,381,175 | 140,290 | 836 | 320 | 1,740 | 5,570 | 4,055 |
| 1907.. | 21,500 | 115,387 | 1,495,895 | 286,256 | 850 | 326 | 2,125 | 4,780 | 4,033 |
| 1908.. | 17,195 | 68,551 | 647,639 | 1,209,110 | 910 | 245 | 5,859 | 5,480 | 4,844 |
| 1909.. | 17,920 | 187,312 | 694,191 | 1,242,088 | 1,094 | 305 | 3,151 | 5,580 | 6,774 |
| 1910.. | 24,711 | 107,660 | 713,994 | 1,299,970 | 1,333 | 270 | 2,620 | 5,132 | 7,415 |
| 1911 | 26,234 | 70,512 | 709,227 | 1,311,723 | ..... | 210 | 3,165 | 4,680 | 11,298 |

| Year. | Gypsum. | Iron. | | | | | | Lithographic Limestone. |
|---|---|---|---|---|---|---|---|---|
| | | Ore. | Bar. | Cast, 1st Fusion. | Cast, 2d Fusion. | Pig. | Steel. | |
| 1898.... | 25,688 | 171,987 | 58,342 | 97 | 84,227 | 84,144 | 120,623 | 12,029 |
| 1899.... | 29,727 | 181,981 | 61,415 | (b) | 92,459 | 83,821 | 134,007 | 11,962 |
| 1900.... | 35,484 | 178,441 | 49,727 | 29 | 89,692 | 82,327 | 135,411 | 16,030 |
| 1901.... | 3,581 | 158,820 | 29,978 | 76 | 76,191 | 72,071 | 109,464 | 9,500 |
| 1902.... | 31,701 | 157,375 | 38,429 | 56 | 81,874 | 83,123 | 115,354 | ..... |
| 1903.... | 30,894 | 162,500 | 36,853 | 41 | 89,804 | 90,168 | 127,141 | 9,890 |
| 1904.... | 22,766 | 180,342 | 37,780 | 40 | 108,025 | 92,200 | 125,483 | 13,836 |
| 1905.... | 46,247 | 182,389 | 36,459 | 24 | 112,875 | 94,242 | 134,755 | 11,360 |
| 1906.... | 50,763 | 203,596 | 38,508 | ..... | 122,115 | 97,812 | 150,129 | ..... |
| 1907.... | 48,975 | 277,280 | 36,883 | *Nil.* | 138,659 | 98,143 | 150,148 | 11,590 |
| 1908.... | 51,314 | 278,681 | 30,740 | *Nil.* | 128,234 | 131,404 | 176,085 | 9,858 |
| 1909.... | 51,630 | 279,514 | 33,448 | *Nil.* | 130,129 | 134,133 | 219,606 | 9,420 |
| 1910.... | 54,397 | 303,844 | 30,881 | *Nil.* | 148,261 | 133,679 | 249,198 | 9,790 |
| 1911.... | 60,290 | 375,409 | 165,683 | *Nil.* | 171,976 | ..... | 339,401 | 8,175 |

(*a*) From the *Uebersicht der Production des Bergwerks-, Hütten-, und Salinen-Betriebes in dem Bayerischen Staate.* (*b*) Not reported.

| Year. | Marl. (For Cement). | Mineral Paint and Chalk. | Pyrites. | Rock Salt. | Soapstone. | Sodium Sulphate. | Sulphuric Acid. |
|---|---|---|---|---|---|---|---|
| 1898.... | 110,757 | 8,748 | 2,304 | 736 | 1,912 | 2,332 | 103,385 |
| 1899.... | 220,716 | 9,287 | 2,516 | 802 | 2,197 | 1,570 | 123,273 |
| 1900.... | 180,032 | 11,507 | 2,120 | 1,298 | 1,977 | 1,821 | 123,910 |
| 1901.... | 76,663 | 84,929 | 2,649 | 1,319 | 2,291 | 1,893 | 115,775 |
| 1902.... | 178,301 | 13,947 | 2,635 | 832 | ..... | ..... | ..... |
| 1903.... | 200,407 | 19,486 | 2,324 | 879 | 1,866 | ..... | ..... |
| 1904.... | 170,698 | 19,107 | 3,427 | 1,139 | 1,709 | ..... | ..... |
| 1905.... | 231,310 | 18,285 | 3,301 | 911 | 1,872 | ..... | ..... |
| 1906.... | 230,271 | 22,304 | 3,918 | 1,053 | ..... | ..... | ..... |
| 1907.... | 230,583 | 21,219 | 5,085 | 1,393 | 1,999 | 1,439 | 161,868 |
| 1908.... | 307,820 | 21,310 | 4,037 | 1,285 | 2,199 | 1,743 | 149,079 |
| 1909.... | 276,974 | 21,692 | 2,952 | 1,860 | 2,329 | 1,265 | 178,371 |
| 1910.... | 273,727 | 22,357 | 4,466 | 1,192 | 3,083 | 1,416 | 171,131 |
| 1911.... | 265,899 | 24,258 | 6,316 | 782 | 3,431 | 2,061 | 170,039 |

## MINERAL PRODUCTION OF PRUSSIA. (*a*)

(Metric tons; 4 marks = $1.)

| Year. | Alum Shale. | Antimony and Alloys. | Arsenic Products. | Arsenic Ore. | Asphalt. | Boracite. | Cadmium. *Kg.* | Coal. |
|---|---|---|---|---|---|---|---|---|
| 1898.... | 107 | 2,612 | 1,624 | 3,298 | 12,822 | 216 | 14,943 | 89,593,528 |
| 1899.... | 145 | 3,003 | 1,469 | 3,265 | 16,458 | 171 | 13,608 | 94,740,829 |
| 1900.... | 103 | 3,025 | 1,585 | 3,531 | 23,891 | 217 | 13,533 | 101,966,158 |
| 1901.... | 611 | 2,404 | 1,446 | 3,050 | 26,450 | 164 | 13,144 | 101,203,807 |
| 1902.... | 219 | 3,542 | 1,514 | 2,909 | 28,035 | 172 | 12,625 | 100,115,315 |
| 1903.... | 580 | 3,224 | 1,583 | 3,538 | 23,518 | 135 | 16,565 | 108,809,384 |
| 1904.... | 106 | 2,774 | 1,573 | 3,527 | 26,348 | 115 | 25,245 | 112,755,621 |
| 1905.... | 97 | 2,795 | 1,493 | 4,022 | 28,872 | 151 | 24,568 | 113,000,657 |
| 1906.... | 634 | 2,953 | 1,551 | 5,430 | 32,270 | 124 | 21,486 | 128,295,948 |
| 1907.... | 154 | 3,515 | 1,591 | 4,224 | 39,243 | 90 | 32,949 | 134,044,080 |
| 1908.... | 80 | 3,596 | 1,646 | 5,015 | 27,444 | 105 | 32,995 | 139,002,378 |
| 1909.... | 60 | 3,841 | 1,849 | 5,731 | 19,509 | 123 | 37,187 | 139,906,194 |
| 1910.... | 46 | 4,969 | 2,068 | 5,789 | 21,595 | 138 | 41,058 | 143,771,612 |
| 1911.... | 63 | 5,411 | 1,862 | 4,476 | 19,956 | 147 | 42,575 | 151,324,030 |

| Year. | Coal. (Lignite.) | Cobalt Ore. | Cobalt Products. | Copper. | Copper and Iron Sulphate. | Copper Ore. | Copper Matte. |
|---|---|---|---|---|---|---|---|
| 1898.... | 26,035,814 | 34 | 44 | 27,216 | 120 | 691,866 | 62 |
| 1899.... | 28,418,598 | 17 | 46 | 20,902 | 154 | 722,884 | 95 |
| 1900.... | 34,007,542 | 4 | 52 | 27,156 | 113 | 747,601 | 4,207 |
| 1901.... | 37,491,412 | 36 | 66 | 28,422 | 78 | 765,241 | 281 |
| 1902.... | 36,228,285 | 76 | 74 | 27,893 | 119 | 751,496 | 346 |
| 1903.... | 38,462,766 | 65 | 87 | 28,386 | 110 | 761,188 | 488 |
| 1904.... | 41,153,576 | 41 | 85 | 27,450 | 95 | 782,049 | 601 |
| 1905.... | 44,148,751 | 22 | 99 | 28,874 | 102 | 769,381 | 1,052 |
| 1906.... | 47,912,721 | 7 | 98 | 29,166 | 94 | 755,812 | 525 |
| 1907.... | 52,660,597 | *Nil.* | 109 | 28,945 | 64 | 755,203 | 499 |
| 1908.... | 55,456,860 | *Nil.* | 100 | 27,301 | 50 | 711,921 | 296 |
| 1909.... | 56,029,554 | *Nil.* | 93 | 28,523 | 55 | 798,448 | 1,935 |
| 1910.... | 56,644,291 | *Nil.* | 94 | 30,244 | 44 | 914,519 | 2,060 |
| 1911.... | 60,531,943 | *Nil.* | 107 | 30,986 | 27 | 868,495 | 996 |

| Year. | Copper Sulphate. | Epsom Salt. | Gold. *Kg.* | Iron. | Iron Ore. | Iron Sulphate. | Lead. |
|---|---|---|---|---|---|---|---|
| 1898..... | 1,701 | 2,061 | 1,036.3 | 5,176,943 | 4,020,809 | 9,144 | 119,346 |
| 1899..... | 1,586 | 1,793 | 1,016.4 | 5,644,614 | 4,295,575 | 10,186 | 116,995 |
| 1900..... | 1,660 | 1,511 | 1,076.6 | 5,781,892 | 4,268,069 | 10,225 | 112,738 |
| 1901..... | 1,951 | 1,952 | 1,087.1 | 5,315,628 | 3,831,670 | 10,239 | 113,939 |
| 1902..... | 1,937 | 761 | 1,138.0 | 5,633,089 | 3,362,887 | 11,214 | 127,283 |
| 1903..... | 2,254 | 421 | 949.5 | 6,614,768 | 3,786,743 | 11,086 | 133,405 |
| 1904..... | 3,364 | 289 | 1,081.9 | 6,573,507 | 3,757,651 | 12,524 | 128,294 |
| 1905..... | 3,065 | 338 | 1,034.9 | 7,106,975 | 4,130,210 | 12,075 | 143,270 |
| 1906..... | 2,724 | 144 | 750.2 | 8,154,880 | 4,713,928 | 12,473 | 140,690 |
| 1907..... | 2,129 | 263 | 771.0 | 8,266,300 | 5,077,773 | 13,014 | 132,386 |
| 1908..... | 3,116 | 398 | 786.6 | 7,989,260 | 4,311,593 | 14,062 | 153,541 |
| 1909..... | 2,500 | 395 | 588.2 | 8,410,824 | 4,389,950 | 18,295 | 156,533 |
| 1910..... | 1,749 | 162 | 566.3 | 9,995,012 | 4,823,606 | 16,119 | 146,993 |
| 1911.... | 2,464 | 114 | 520. | 10,477,263 | 4,948,711 | 15,468 | 147,538 |

| Year. | Lead ore. | Litharge. | Manganese Ore. | Nickel. | Nickel Ore. | Nickel Sulphate. | Ocher and Mineral Paints. |
|---|---|---|---|---|---|---|---|
| 1898..... | 133,637 | 2,360 | 42,232 | 1,108 | 79 | 127 | 2,376 |
| 1899..... | 128,942 | 2,482 | 60,379 | 1,115 | 91 | 123 | 2,770 |
| 1900..... | 133,483 | 2,366 | 58,016 | 1,376 | 3,896 | 115 | 2,850 |
| 1901..... | 139,285 | 2,885 | 55,866 | 1,660 | 9,922 | 120 | 2,800 |
| 1902..... | 152,282 | 2,516 | 48,882 | 1,605 | 11,816 | 159 | 2,780 |
| 1903..... | 151,746 | 2,710 | 47,110 | 1,945 | 14,058 | 173 | 2,850 |
| 1904..... | 150,328 | 2,517 | 52,092 | 2,333 | 13,518 | 207 | 3,200 |
| 1905..... | 138,928 | 2,272 | 51,048 | 2,631 | 10,432 | 220 | 3,170 |
| 1906..... | 127,322 | 2,744 | 51,881 | 2,648 | 7,472 | 187 | 3,635 |
| 1907..... | 133,528 | 2,959 | 72,442 | 2,093 | 7,557 | 189 | 3,707 |
| 1908..... | 141,316 | 4,190 | 67,241 | 2,622 | 8,238 | 181 | 3,183 |
| 1909..... | 158,811 | 2,365 | 76,741 | 3,186 | 10,095 | 163 | 3,435 |
| 1910..... | 146,830 | 3,076 | 80,325 | 3,497 | 10,053 | 213 | 142 |
| 1911..... | 139,235 | 3,441 | 86,902 | 3,744 | 9,609 | 244 | ..... |

| Year. | Petroleum. | Potassium salts. | | Pyrites. | Quicksilver. *Kg.* | Salt. | |
|---|---|---|---|---|---|---|---|
| | | Kainite. | All other. | | | Common. | Rock. |
| 1898..... | 2,545 | 744,240 | 718,957 | 128,077 | 4,717 | 286,051 | 329,959 |
| 1899..... | 3,405 | 744,657 | 941,055 | 134,564 | 2,611 | 288,588 | 331,943 |
| 1900..... | 27,731 | 857,271 | 1,264,993 | 159,186 | 1,711 | 287,005 | 354,603 |
| 1901..... | 24,098 | 1,068,237 | 1,131,703 | 148,457 | 1,713 | 290,869 | 353,557 |
| 1902..... | 29,520 | 943,450 | 1,344,541 | 155,410 | 1,828 | 291,296 | 359,006 |
| 1903..... | 41,733 | 1,118,270 | 1,344,038 | 159,234 | 2,145 | 317,475 | 409,199 |
| 1904..... | 67,604 | 1,261,930 | 1,447,323 | 163,209 | 3,030 | 328,933 | 394,910 |
| 1905..... | 57,741 | 1,580,530 | 1,734,033 | 174,641 | 2,597 | 328,051 | 436,942 |
| 1906..... | 59,196 | 1,923,088 | 1,937,181 | 186,849 | 5,084 | 339,675 | 492,339 |
| 1907..... | 80,255 | 1,839,409 | 2,070,978 | 184,962 | 5,080 | 353,290 | 480,563 |
| 1908..... | 113,002 | 2,037,203 | 2,192,188 | 204,992 | 4,423 | 359,003 | 478,346 |
| 1909..... | 113,518 | 2,431,401 | 2,436,319 | 189,773 | 5,213 | 344,685 | 491,071 |
| 1910..... | 110,996 | 3,119,400 | 2,584,565 | 203,596 | 4,492 | 351,698 | 500,978 |
| 1911..... | 98,611 | 3,502,762 | 2,920,725 | 203,249 | 2,861 | 337,583 | 527,034 |

| Year. | Silver. *Kg.* | Silver and Gold Ores. | Sulphur. | Sulphuric Acid. | Tin. | Zinc. | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Ore. | Metal. | Sulphate. |
| 1898..... | 291,969 | 43 | 1,757 | 531,838 | 979 | 641,671 | 154,643 | 4,158 |
| 1899..... | 293,858 | 7 | 1,419 | 573,733 | 1,461 | 663,763 | 152,987 | 4,864 |
| 1900..... | 266,577 | 1 | 1,207 | 593,109 | 2,010 | 636,068 | 155,760 | 3,742 |
| 1901..... | 246,286 | 6 | 772 | 609,041 | 1,443 | 644,504 | 166,223 | 3,369 |
| 1902..... | 273,901 | 17 | 250 | 677,798 | 2,753 | 699,392 | 174,892 | 3,381 |
| 1903..... | 255,722 | 13 | 16 | 724,784 | 3,042 | 679,320 | 182,472 | 3,586 |
| 1904..... | 252,020 | 8 | 16 | 868,424 | 4,193 | 710,599 | 192,903 | 3,696 |
| 1905..... | 266,072 | 4 | 14 | 921,219 | 5,196 | 727,104 | 198,179 | 3,506 |
| 1906..... | 264,427 | 239 | 16 | 980,188 | 6,570 | 702,933 | 205,632 | 3,630 |
| 1907..... | 249,348 | 34 | 7 | 1,004,599 | 5,819 | 696,039 | 207,849 | 3,057 |
| 1908..... | 274,154 | 7 | 706 | 997,931 | 5,330 | 703,394 | 212,991 | 3,223 |
| 1909..... | 271,779 | 2 | 1,096 | 1,006,787 | 8,943 | 720,139 | 214,551 | 3,434 |
| 1910..... | 277,777 | 0.2 | 1,239 | 1,164,015 | 11,345 | 714,855 | 216,362 | 3,875 |
| 1911..... | 277,981 | ..... | 1,239 | 1,219,879 | 12,335 | 696,903 | 230,995 | 4,127 |

(*a*) From *Zeitschrift für das Berg, Hütten, und Salinenwesen.*

## MINERAL IMPORTS OF GERMANY. (*a*)

| Year. | Aluminum Refined and Crude. | Ammonium Sulphate. | Antimony. | Antimony and Arsenic Ores. | Asbestos, Crude. | Asphalt. | Bituminous Rock. | Barium Chloride. | Barytes. (*b*) |
|---|---|---|---|---|---|---|---|---|---|
| 1900 ... | 943 | 23,105 | 1,461 | 1,291 | 6,850 | 80,765 | 48,986 | 3,062 | 7,282 |
| 1901 ... | 1,090 | 44,408 | 1,494 | 1,098 | 5,500 | 62,299 | 41,733 | 1,768 | 5,764 |
| 1902 ... | 1,100 | 42,252 | 1,495 | 1,231 | 3,415 | 88,536 | 36,791 | 2,135 | 5,040 |
| 903 ... | 1,155 | 35,168 | 2,281 | 1,741 | 5,727 | 94,377 | 40,873 | 2,374 | 5,534 |
| 1904 ... | 2,422 | 35,166 | 2,003 | 1,687 | 5,251 | 85,049 | 38,812 | 2,428 | 6,742 |
| 1905 ... | 3,252 | 48,005 | 1,680 | 567 | 7,830 | 3,461 | 64,196 | 2,114 | 7,981 |
| 1906 ... | 3,886 | 35,366 | 2,044 | 2,417 | 9,828 | 15,095 | 118,238 | 2,559 | 17,246 |
| 1907 ... | 3,974 | 33,522 | 2,496 | 4,913 | 11,096 | 4,793 | 128,257 | 2,781 | 12,588 |
| 1908 ... | 3,204 | 47,265 | 2,670 | 2,073 | 10,034 | 2,587 | 130,063 | 2,256 | 19,969 |
| 1909 ... | 8,696 | 58,132 | 2,719 | 2,912 | 11,928 | 1,209 | 98,378 | 1,907 | 14,560 |
| 1910 ... | 9,892 | 31,400 | 2,982 | 3,347 | 11,729 | 2,932 | 117,763 | 1,955 | 5,782 |
| 1911 ... | 10,454 | 24,463 | 3,607 | 6,429 | 12,334 | 133,635 | 17,476 | 2,002 | 7,926 |
| 1912 ... | 18,112 | 23,098 | 3,400 | 2,565 | 14,790 | 147,784 | 18,409 | 3,674 | 18,666 |

| Year. | Borax. | Bauxite. | Calcium Carbide. | Cement. | Chalk (*d*), Crude White. | Chrome Ore. | Coal. | | Coke. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Bitum., Arthracite Cannel. | Lignitic. | |
| 1900 ... | 2,403 | 29,383 | 7,703 | 79,303 | (*d*)63,929 | 18,728 | 7,384,049 | 7,960,313 | 512,690 |
| 1901 ... | 2,537 | 24,113 | 9,526 | 87,262 | (*d*)29,611 | 18,222 | 6,297,389 | 8,108,943 | 400,197 |
| 1902 ... | 2,057 | 26,698 | 11,287 | 52,018 | (*d*)26,408 | 10,152 | 6,425,658 | 7,882,010 | 382,488 |
| 1903 ... | 2,567 | 22,316 | 14,081 | 49,870 | (*d*)33,362 | 13,919 | 6,766,513 | 7,962,123 | 432,819 |
| 1904 ... | 2,603 | 27,849 | 14,840 | 60,188 | (*d*)32,581 | 18,132 | 7,299,042 | 7,669,099 | 550,302 |
| 1905 ... | 2,802 | 39,137 | 17,256 | 148,118 | (*d*)35,529 | 11,998 | 9,399,693 | 7,945,261 | 713,619 |
| 1906 ... | 3,044 | 43,177 | 22,819 | 233,119 | 18,871 | 17,124 | 9,253,711 | 8,430,441 | 565,561 |
| 1907 ... | 2,014 | 59,989 | 25,834 | 241,475 | 16,035 | 19,508 | 13,729,849 | 8,963,103 | 584,220 |
| 1908 ... | 1,903 | 48,064 | 29,024 | 168,504 | 17,606 | 16,974 | 11,661,503 | 8,581,966 | 575,091 |
| 1909 ... | 2,550 | 45,543 | 26,956 | 224,178 | 15,924 | 22,018 | 12,198,634 | 8,166,479 | 673,012 |
| 1910 ... | 3,181 | 56,287 | 30,712 | 242,663 | 17,700 | 24,470 | 11,195,593 | 7,397,719 | 622,452 |
| 1911 ... | 5,358 | 37,155 | 36,994 | 253,023 | 23,717 | 16,022 | 10,913,948 | 7,069,064 | 598,958 |
| 1912 ... | 7,978 | 36,348 | 47,984 | 228,896 | 28,031 | 23,201 | 10,380,482 | 7,266,116 | 589,713 |

| Year. | Peat and Peat Coke. | Briquettes. | Cobalt and Nickel Ore. | Copper. | | | | Copperas | Cryolite. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Ore. and Matte. | Ingots. | Bars, Wire and Sheets. | Sulphate. | | |
| 1900 ... | 19,807 | 137,153 | 13,032 | 10,930 | 83,503 | 906 | 2,369 | 752 | 1,460 |
| 1901 ... | 15,102 | 92,037 | 12,186 | 4,614 | 58,620 | 786 | 1,211 | 501 | 1,249 |
| 1902 ... | 16,696 | 81,854 | 14,630 | 14,630 | 76,050 | 540 | 2,499 | 807 | 1,332 |
| 1903 ... | 14,640 | 84,635 | 36,927 | 13,714 | 83,261 | 568 | 1,691 | 778 | 1,082 |
| 1904 ... | 9,071 | 125,477 | 14,555 | 7,949 | 110,231 | 719 | 1,735 | 765 | 1,139 |
| 1905 ... | 11,439 | 191,753 | 39,590 | 10,137 | 102,218 | 927 | 2,180 | 666 | 1,143 |
| 1906 ... | 19,428 | 162,650 | 22,557 | 9,941 | 126,071 | 409 | 1,702 | 621 | (*k*) |
| 1907 ... | 15,238 | 195,403 | 29,296 | 19,295 | 124,116 | 772 | 4,519 | 1,165 | (*k*) |
| 1908 ... | 15,266 | 192,391 | 17,402 | 17,456 | 157,669 | 952 | 5,078 | 7,234 | (*k*) |
| 1909 ... | 13,208 | 211,058 | 10,186 | 26,488 | 154,673 | 416 | 6,550 | 5,954 | (*k*) |
| 1910 ... | 16,188 | 241,267 | 9,937 | 22,194 | 181,551 | 403 | 3,952 | 4,336 | (*k*) |
| 1911 ... | 14,517 | 210,933 | 14,897 | 23,327 | 191,590 | 520 | 4,145 | 3,323 | (*k*) |
| 1912 ... | 11,040 | 187,736 | 14,987 | 23,192 | 200,608 | 332 | 7,074 | 5,925 | (*k*) |

| Year. | Gold, Silver and Platinum Ores. | Graphite | Gypsum. | Iodine. | Iron. | | Lead. | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Ore. | Pig. | Ore. | Pig and Scrap. | Lead White. |
| 1900 ... | 9,153 | 22,495 | 7,571 | 236 | 4,107,840 | 726,712 | 51,338 | 70,252 | 698 |
| 1901 ... | 8,764 | 17,374 | 7,622 | 266 | 4,370,022 | 267,503 | 100,196 | 52,886 | 423 |
| 1902 ... | 6,585 | 19,392 | 8,177 | 220 | 3,957,403 | 143,040 | 71,078 | 39,006 | 357 |
| 1903 ... | 4,386 | 20,953 | 8,328 | 320 | 5,225,336 | 158,347 | 67,573 | 52,440 | 442 |
| 1904 ... | 5,960 | 23,533 | 9,550 | 272 | 6,061,127 | 178,256 | 83,807 | 61,388 | 622 |
| 1905 ... | 6,225 | 26,143 | 11,247 | 377 | 6,085,196 | 158,700 | 92,667 | 78,528 | 2,488 |
| 1906 ... | 4,819 | 28,175 | 11,062 | 297 | 7,629,730 | 409,083 | 90,027 | 71,191 | 2,342 |
| 1907 ... | 3,601 | 29,405 | 14,662 | 147 | 8,476,076 | 443,624 | 137,861 | 75,200 | 3,037 |
| 1908 ... | 1,922 | 34,491 | 14,599 | 194 | 7,732,949 | 252,779 | 133,597 | 77,218 | 3,558 |
| 1909 ... | 1,759 | 29,191 | 11,285 | 369 | 8,366,599 | 134,230 | 111,017 | 76,930 | 2,890 |
| 1910 ... | 2,552 | 30,733 | 10,873 | 363 | 9,816,822 | 136,330 | 112,151 | 81,541 | 2,780 |
| 1911 ... | 2,947 | 32,812 | 11,973 | 303 | 10,812,595 | 129,850 | 143,598 | 100,515 | 3,938 |
| 1912 ... | 2,200 | 37,633 | 10,628 | 260 | 12,120,010 | 135,722 | 122,847 | 93,585 | 2,709 |

| Year. | Magnesite. | Manganese Ore. | Mineral Pigments. | Nickel. | Ozokerite. | Petroleum products. | | Phosphorus. |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Illuminating Oil. | Lubricating Oil. | |
| 1900.... | 13,920 | 204,420 | 12,107 | 1,712 | 3,457 | 989,361 | 124,505 | 381 |
| 1901.... | 8,897 | 222,010 | 9,403 | 1,947 | 1,981 | 985,904 | 118,999 | 313 |
| 1902.... | 12,237 | 204,647 | 7,719 | 1,458 | 1,585 | 1,006,829 | 125,667 | 350 |
| 1903.... | 14,958 | 223,709 | 9,888 | 1,507 | 1,663 | 1,067,697 | 147,837 | 222 |
| 1904.... | 15,877 | 255,760 | 10,494 | 1,712 | 1,300 | 1,076,324 | 142,929 | 220 |
| 1905.... | 19,459 | 262,311 | 11,473 | 1,955 | 1,114 | 1,070,252 | 143,926 | 198 |
| 1906.... | 25,527 | 331,171 | 3,960 | 3,478 | 1,303 | 984,134 | 180,989 | 208 |
| 1907.... | 30,857 | 393,327 | 2,166 | 2,182 | 1,653 | 1,115,205 | 226,609 | 165 |
| 1908.... | 28,305 | 334,133 | 1,635 | 3,058 | 1,447 | 1,123,632 | 216,887 | 141 |
| 1909.... | 29,994 | 384,445 | 13,804 | 3,745 | 1,447 | 1,085,839 | 216,987 | 179 |
| 1910.... | 40,218 | 487,872 | 15,100 | 4,606 | 1,729 | 1,135,886 | 230,516 | 169 |
| 1911.... | 47,930 | 420,709 | 15,703 | 2,598 | 1,591 | 955,482 | 260,242 | 200 |
| 1912.... | 69,064 | 523,125 | 2,294 | 2,027 | 1,479 | 988,640 | 280,018 | 205 |

| Year. | Phosphate Rock. | Potassium salts. | | | | | | | Pumicestone (g) | Pyrites. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Chloride. | Cyanide. (f) | Iodide. | Nitrate. | Carbonate. | Hydroxide. | Sulphate. | | |
| 1900.... | 320,138 | 484 | 2 | 10 | 2,047 | 1,522 | 283 | 856 | 2,154 | 457,679 |
| 1901.... | 351,155 | 462 | 2 | 1,529 | 1,758 | 1,529 | 165 | 680 | 2,336 | 488,633 |
| 1902.... | 430,043 | 261 | 3 | 10 | 1,889 | 2,112 | 42 | 266 | 2,070 | 482,095 |
| 1903.... | 461,092 | 40 | 3 | 8 | 2,163 | 1,850 | 52 | 81 | 2,697 | 519,317 |
| 1904.... | 508,634 | 47 | 2 | 10 | 2,349 | 1,955 | 61 | 121 | 3,000 | 503,503 |
| 1905.... | 501,048 | 223 | 3 | 30 | 2,156 | 1,693 | 24 | 131 | 3,240 | 552,184 |
| 1906.... | 531,195 | 181 | 3 | 18 | 1,918 | 2,099 | 44 | 257 | 5,463 | 579,355 |
| 1907.... | 579,505 | 1,615 | 1 | 8 | 1,815 | 2,304 | 92 | 141 | 5,443 | 742,526 |
| 1908.... | 736,127 | 49 | 4 | 7 | 2,200 | 1,773 | 50 | 169 | 6,154 | 659,871 |
| 1909.... | 663,400 | 55 | 2 | 4 | 2,853 | 1,750 | 64 | 101 | 6,639 | 691,213 |
| 1910.... | 723,271 | 72 | 2 | 8 | 1,979 | 2,366 | 63 | 66 | 7,446 | 792,735 |
| 1911.... | 831,027 | 1,160 | 33 | 13 | 2,114 | 2,616 | 67 | 61 | 9,659 | 862,214 |
| 1912.... | 902,844 | 46 | 5 | 11 | 597 | 2,321 | 62 | 44 | 10,051 | 1,076,511 |

| Year. | Quicksilver. | Salt. | Slag and Slag Wool. | Sodium Salts. | | | Strontianite. (n) |
|---|---|---|---|---|---|---|---|
| | | | | Soda, Calcined. | Nitrate (Chile Saltpeter.) | Sulphate and Sulphite. | |
| 1900..... | 555 | 21,738 | 974,947 | 373 | 484,544 | 9,450 | 8,701 |
| 1901..... | 651 | 23,901 | 733,931 | 178 | 529,568 | 7,921 | 19,739 |
| 1902..... | 648 | 26,404 | 831,282 | 121 | 467,024 | 7,308 | 34,035 |
| 1903..... | 674 | 20,118 | 877,394 | 114 | 467,130 | 6,058 | 24,183 |
| 1904..... | 691 | 18,743 | 846,738 | 179 | 506,172 | 9,598 | 18,055 |
| 1905..... | 729 | 20,726 | 888,665 | 143 | 540,916 | 4,752 | 13,720 |
| 1906..... | 698 | 16,997 | 813,388 | 189 | 593,218 | 7,405 | 5,212 |
| 1907..... | 831 | 23,109 | 568,046 | 257 | 591,131 | 10,446 | 5,595 |
| 1908..... | 648 | 24,975 | 562,853 | 293 | 604,457 | 4,404 | 4,211 |
| 1909..... | 723 | 19,319 | 492,771 | 181 | 665,450 | 9,214 | 4,277 |
| 1910..... | 836 | 30,443 | 766,320 | 105 | 749,945 | 9,302 | 4,852 |
| 1911..... | 919 | 29,067 | 685,943 | 559 | 730,939 | 5,976 | 3,251 |
| 1912..... | 990 | 17,887 | 1,248,693 | 1,987 | 812,898 | 5,609 | 4,259 |

| Year. | Sulphur. | Sulphuric Acid. | Super-phosphate. | Tin, Crude. | Zinc. | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Ore. | Spelter. | Drawn or Rolled. | Zinc-white, Zinc-gray, Lithophone. |
| 1900.... | 40,689 | 20,634 | 72,062 | 12,454 | 68,982 | 24,263 | 145 | 4,884 |
| 1901.... | 32,750 | 18,502 | 107,365 | 12,910 | 75,533 | 21,250 | 306 | 3,673 |
| 1902.... | 32,798 | 22,205 | 109,374 | 13,760 | 61,407 | 25,946 | 134 | 3,986 |
| 1903.... | 41,545 | 13,418 | 82,740 | 13,925 | 67,156 | 25,749 | 237 | 4,667 |
| 1904.... | 41,030 | 16,087 | 91,288 | 14,352 | 93,515 | 26,389 | 151 | 6,461 |
| 1905.... | 39,989 | 33,837 | 109,666 | 13,501 | 126,577 | 29,583 | 54 | 7,802 |
| 1906.... | 41,390 | 74,536 | 76,384 | 14,098 | 178,953 | 39,314 | 97 | 9,140 |
| 1907.... | 44,700 | 59,753 | 62,877 | 12,814 | 184,703 | 28,459 | 134 | 10,189 |
| 1908.... | 44,066 | 61,391 | 71,879 | 14,039 | 199,840 | 32,622 | 286 | 7,080 |
| 1909.... | 42,941 | 74,384 | 80,512 | 13,537 | 201,110 | 44,514 | 99 | 7,002 |
| 1910.... | 46,796 | 86,743 | 78,873 | 14,297 | 240,584 | 39,328 | 246 | 9,239 |
| 1911.... | 46,054 | 99,653 | 71,119 | 14,500 | 262,399 | 48,355 | 467 | 7,697 |
| 1912.... | 42,284 | 98,573 | 62,400 | 15,550 | 293,090 | 56,937 | 1,003 | 9,367 |

**MINERAL EXPORTS OF GERMANY. (a)**

| Year. | Aluminum Refined and crude. | Aluminum Wares, etc. | Aluminum Sulphate. | Ammonium. | | Antimony and Arsenic Ores. | Antimony. | |
|---|---|---|---|---|---|---|---|---|
| | | | | Carbonate and Chloride. | Sulphate. | | Metallic. | Salts. |
| 1900.... | 269 | 2,398 | 29,372 | 3,196 | 2,431 | 284 | 131 | 786 |
| 1901.... | 282 | 2,270 | 31,171 | 3,196 | 9,842 | 283 | 76 | 826 |
| 1902.... | 410 | 2,608 | 34,005 | 3,351 | 5,744 | 410 | 105 | 954 |
| 1903.... | 353 | 2,865 | 28,513 | 2,778 | 5,592 | 427 | 83 | 873 |
| 1904.... | 407 | 3,077 | 29,311 | 3,106 | 10,696 | 486 | 250 | 964 |
| 1905.... | 1,192 | 3,476 | 34,776 | 3,579 | 27,589 | 287 | 218 | 1,097 |
| 1906.... | 1,111 | 1,321 | 25,937 | 3,555 | 37,288 | 548 | 221 | 997 |
| 1907.... | 1,119 | 1,142 | 24,759 | 3,118 | 57,439 | 930 | 255 | 1,168 |
| 1908.... | 590 | 642 | 22,376 | 1,161 | 73,186 | 588 | 146 | 1,030 |
| 1909.... | 492 | 1,273 | 58,723 | 1,093 | 58,722 | 577 | 160 | 1,090 |
| 1910.... | 616 | 1,755 | 93,069 | 1,500 | 93,069 | 571 | 198 | 1,047 |
| 1911.... | 768 | 1,331 | 30,107 | 4,895 | 74,410 | 612 | 298 | 1,208 |
| 1912.... | 2,045 | 2,006 | 32,421 | 4,527 | 56,949 | 562 | 132 | 1,152 |

| Year. | Arsenic. | | Asbestos. | Barytes. (b) | Barium. | | Bauxite. | Borax. | Bromine. |
|---|---|---|---|---|---|---|---|---|---|
| | Metallic. | White, etc. | Crude. | | Chloride and Salts of. | White. | | | |
| 1900 ... | 14 | 1,573 | 496 | 59,012 | 5,927 | 2,717 | 44 | 2,894 | 191 |
| 1901 ... | 28 | 1,534 | 638 | 67,526 | 6,803 | 2,765 | 137 | 2,563 | 228 |
| 1902 ... | 46 | 2,036 | 709 | 56,026 | 7,358 | 2,922 | 32 | 2,836 | 153 |
| 1903 ... | 32 | 1,903 | 513 | 72,455 | 8,417 | 3,187 | 19 | 2,779 | 155 |
| 1904 ... | 50 | 1,956 | 738 | 69,564 | 8,596 | 3,777 | 21 | 2,741 | 208 |
| 1905 ... | 40 | 1,753 | 1,173 | 81,134 | 9,550 | 4,382 | 6 | 2,720 | 156 |
| 1906 ... | ..... | 2,282 | 1,938 | 90,819 | 6,541 | 10,721 | 398 | 2,795 | 172 |
| 1907 ... | (m)45 | 1,733 | 1,707 | 111,209 | 4,189 | 8,454 | 517 | 3,049 | 118 |
| 1908 ... | (m)65 | 1,956 | 1,345 | 91,111 | 3,389 | 5,190 | 783 | 2,379 | 227 |
| 1909 ... | (m)54 | 1,012 | 1,740 | 90,555 | 5,340 | 4,888 | 1,116 | 2,735 | 206 |
| 1910 ... | (m)57 | 1,507 | 1,537 | 114,264 | 6,403 | 5,528 | 863 | 2,916 | 225 |
| 1911 ... | 71 | 1,973 | 1,503 | 128,452 | 6,180 | 6,834 | 960 | 3,199 | 229 |
| 1912 ... | 73 | 2,369 | 1,872 | 142,681 | 8,096 | 8,242 | 400 | 3,275 | 187 |

| Year. | Coke. | Peat and Peat Coke. | Briquets. | Cobalt and Nickel Ore. | Copper. | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Ore and Matte. | Bars, Sheets and Wire. | Ingots. | Sulphate |
| 1900.... | 2,229,188 | 8,849 | 550,222 | 186 | 25,686 | 9,787 | 5,505 | 1,881 |
| 1901 .. | 2,096,931 | 11,588 | 529,765 | 96 | 26,678 | 7,700 | 5,097 | 1,942 |
| 1902.... | 2,182,383 | 13,410 | 697,799 | 3 | 17,031 | 10,599 | 4,678 | 1,366 |
| 1903.... | 2,523,351 | 16,986 | 895,145 | 1 | 15,986 | 10,715 | 4,333 | 1,880 |
| 1904.... | 2,716,855 | 14,830 | 917,526 | 83 | 19,235 | 12,594 | 4,223 | 2,231 |
| 1905.... | 2,761,080 | 16,009 | 936,694 | 107 | 28,908 | 10,006 | 5,958 | 2,180 |
| 1906.... | 3,415,347 | 15,680 | 1,095,029 | (i) | 6,414 | 10,728 | 7,241 | 3,018 |
| 1907.... | 3,792,580 | 25,746 | 1,260,135 | (i) | 20,950 | 13,411 | 6,113 | 2,016 |
| 1908.... | 3,577,496 | 26,817 | 1,493,054 | (i) | 21,729 | 17,209 | 6,868 | 2,994 |
| 1909.... | 3,444,791 | 23,579 | 1,620,460 | (i) | 22,437 | 15,395 | 6,495 | 1,290 |
| 1910.... | 4,125,898 | 20,360 | 1,988,177 | (i) | 23,751 | 19,351 | 7,654 | 2,108 |
| 1911.... | 4,555,477 | 35,855 | 2,477,492 | (i) | 27,396 | 19,669 | 7,106 | 3,346 |
| 1912.... | 5,849,020 | 53,407 | 2,746,536 | (i) | 19,534 | 20,245 | 7,673 | 3,812 |

| Year. | Bromine Salts. | Calcium. | | Cement. | Chalk. Crude White. | Chromium. | | Coal. | |
|---|---|---|---|---|---|---|---|---|---|
| | | Carbide. | Chloride. | | | Ore. | Alum. | Bituminous Anthracite and Cannel. | Lignitic. |
| 1900 ... | 255 | 224 | 1,315 | 600,386 | (d)11,860 | 427 | 1,192 | 15,275,805 | 52,795 |
| 1901 ... | 249 | 275 | 888 | 560,612 | (d)14,134 | 581 | 1,299 | 15,269,267 | 21,718 |
| 1902 ... | 357 | 126 | 1,346 | 699,378 | (d) 8,475 | 846 | 1,758 | 16,101,141 | 21,766 |
| 1903 ... | 435 | 335 | 1,831 | 742,381 | (d)12,211 | 37 | 1,921 | 17,389,934 | 22,499 |
| 1904 ... | 411 | 608 | 2,381 | 635,248 | (d)11,359 | 47 | 2,432 | 17,996,726 | 22,135 |
| 1905 ... | 634 | 709 | 2,831 | 675,664 | (d)13,081 | 43 | 2,507 | 18,156,998 | 20,118 |
| 1906 ... | 643 | 545 | (l) | 736,579 | 4,287 | (h) 36 | 2,942 | 19,550,964 | 18,759 |
| 1907 ... | 655 | 918 | (l) | 692,982 | 2,919 | (h) 149 | 3,110 | 20,056,503 | 22,065 |
| 1908 ... | 506 | 844 | (l) | 528,847 | 2,108 | (h) 110 | 3,215 | 21,190,777 | 27,877 |
| 1909 ... | 486 | 968 | (l) | 611,893 | 4,395 | (h)5,023 | 3,023 | 23,350,705 | 39,815 |
| 1910 ... | 323 | 1,482 | (l) | 725,356 | 3,359 | 386 | 3,998 | 24,257,651 | 62,441 |
| 1911 ... | ..... | 2,120 | (l) | 845,850 | 1,537 | 1,795 | 2,815 | 27,412,218 | 58,071 |
| 1912 ... | ..... | 971 | (l) | 1,056,495 | 2,890 | 778 | 3,204 | 31,143,115 | 56,966 |

| Year. | Copperas. | Cryolite. | Fluorspar. | Graphite. | Gypsum. | Iodine. | Iron. | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Ore. | Pig. |
| 1900..... | 3,829 | 315 | 12,749 | 2,068 | 39,933 | 29 | 3,247,888 | 129,409 |
| 1901..... | 4,125 | 367 | 13,436 | 1,667 | 40,397 | 27 | 2,389,870 | 150,448 |
| 1902..... | 4,360 | 486 | 14,177 | 1,691 | 42,859 | 24 | 2,868,068 | 374,256 |
| 1903..... | 3,986 | 349 | 13,028 | 1,810 | 51,874 | 29 | 3,343,510 | 418,072 |
| 1904..... | 3,514 | 310 | 13,540 | 1,815 | 55,043 | 30 | 3,440,846 | 225,897 |
| 1905..... | 4,495 | 286 | 15,019 | 1,971 | 52,886 | 27 | 3,698,563 | 380,824 |
| 1906..... | 4,712 | (k) | 15,493 | 2,013 | 63,516 | 46 | 3,851,791 | 479,772 |
| 1907..... | 6,212 | (k) | 16,624 | 2,176 | 70,737 | 44 | 3,904,400 | 275,170 |
| 1908..... | 4,393 | (k) | 14,925 | 2,469 | 60,992 | 51 | 3,067,737 | 257,849 |
| 1909..... | 2,232 | (k) | 14,534 | 2,377 | 63,220 | 59 | 2,825,007 | 471,045 |
| 1910..... | 2,929 | (k) | 17,988 | 3,424 | 89,590 | 70 | 2,952,634 | 786,854 |
| 1911..... | 4,151 | (k) | 23,073 | 3,822 | 102,754 | 73 | 2,581,698 | 829,393 |
| 1912..... | 3,302 | (k) | 21,023 | 4,501 | 108,137 | 79 | 2,309,628 | 1,015,957 |

| Year. | Lead. | | | | | Lime, Chloride of. | Magnesite. | Magnesium Chloride. | Manganese Ore. |
|---|---|---|---|---|---|---|---|---|---|
| | Ore. | Pig and Scrap. | Litharge. | White. | Red. | | | | |
| 1900 ... | 1,309 | 18,825 | 3,577 | 15,126 | 6,603 | 25,954 | 2,392 | 13,375 | 2,454 |
| 1901 ... | 891 | 20,820 | 4,876 | 16,966 | 7,776 | 32,705 | 2,485 | 16,102 | 5,584 |
| 1902 ... | 2,024 | 23,100 | 4,072 | 19,070 | 8,372 | 29,694 | 2,955 | 14,757 | 4,528 |
| 1903 ... | 1,270 | 30,243 | 5,175 | 20,765 | 7,617 | 28,849 | 2,812 | 17,008 | 11,138 |
| 1904 ... | 1,312 | 23,169 | 5,410 | 16,638 | 7,544 | 30,078 | 1,917 | 16,706 | 5,536 |
| 1905 ... | 1,496 | 32,515 | 4,466 | 16,478 | 8,902 | 30,667 | 2,552 | 21,673 | 4,116 |
| 1906 ... | 1,915 | 27,067 | 2,493 | 14,022 | 9,450 | 29,485 | 2,843 | 26,708 | 2,555 |
| 1907 ... | 1,296 | 38,259 | 4,470 | 13,651 | 9,371 | 24,946 | 3,264 | 29,566 | 3,554 |
| 1908 ... | 1,189 | 29,967 | 5,242 | 13,733 | 9,602 | 23,895 | 4,021 | 27,525 | 2,333 |
| 1909 ... | 2,556 | 31,674 | 4,750 | 10,583 | 9,058 | 27,314 | 3,702 | 31,334 | 4,488 |
| 1910 ... | 2,382 | 31,025 | 4,865 | 13,595 | 10,444 | 24,716 | 5,399 | 35,352 | 4,557 |
| 1911 ... | 3,746 | 32,063 | 5,436 | 14,962 | 11,321 | 27,107 | 4,496 | 43,896 | 9,615 |
| 1912 ... | 3,264 | 38,114 | 6,480 | 12,701 | 10,101 | 32,085 | 6,912 | 39,080 | 7,117 |

| Year. | Mineral Pigments. | Nickel. | Ozokerite. | Petroleum Products. (f) | | Phosphorus. | Phosphate Rock. |
|---|---|---|---|---|---|---|---|
| | | | | Illuminating Oil. | Lubricating Oil. | | |
| 1900..... | 13,958 | 268 | 1,592 | 843 | 1,455 | 170 | 1,123 |
| 1901..... | 12,671 | 390 | 1,700 | 655 | 963 | 149 | 2,260 |
| 1902..... | 14,392 | 689 | 1,856 | 824 | 1,177 | 260 | 1,103 |
| 1903..... | 15,161 | 700 | 2,027 | 701 | 1,975 | 286 | 4,342 |
| 1904..... | 16,395 | 1,203 | 2,447 | 760 | 1,763 | 236 | 3,222 |
| 1905..... | 17,603 | 1,034 | 2,757 | 7,286 | 1,746 | 228 | 3,720 |
| 1906..... | 4,290 | 954 | 509 | 673 | 9,982 | 228 | 5,484 |
| 1907..... | 4,097 | 930 | 692 | 770 | 10,552 | 165 | 1,494 |
| 1908..... | 15,675 | 1,349 | 921 | 1,008 | 10,852 | 160 | 1,196 |
| 1909..... | 18,130 | 1,606 | 1,300 | 588 | 11,621 | 168 | 5,429 |
| 1910..... | 19,355 | 1,381 | 1,642 | 472 | 17,141 | 160 | 5,044 |
| 1911..... | 22,426 | 1,592 | 1,295 | 274 | 18,905 | 192 | 10,591 |
| 1912..... | 2,135 | 1,672 | 1,135 | 244 | 19,635 | 219 | 7,032 |

| Year. | Potassium Salts. | | | | | | Potassium and Potassium-Magnesium Sulphate. | Pumice Stone. (g) | Pyrites |
|---|---|---|---|---|---|---|---|---|---|
| | Carbonate | Cyanide. (f) | Chloride. | Hydroxide. | Iodide. | Nitrate. | | | |
| 1900 ... | 15,761 | 1,338 | 114,469 | 15,379 | 138 | 14,744 | 38,125 | 561 | 24,936 |
| 1901 ... | 15,567 | 2,089 | 118,959 | 14,892 | 145 | 13,439 | 37,216 | 699 | 23,680 |
| 1902 ... | 14,041 | 3,257 | 106,925 | 13,804 | 152 | 9,734 | 40,487 | 691 | 35,370 |
| 1903 ... | 13,121 | 2,017 | 125,302 | 13,006 | 154 | 9,671 | 56,455 | 794 | 32,611 |
| 1904 ... | 10,777 | 3,290 | 140,765 | 24,963 | 174 | 10,405 | 64,400 | 943 | 30,666 |
| 1905 ... | 11,963 | 4,005 | 156,440 | 22,246 | 170 | 12,140 | 67,286 | 939 | 35,195 |
| 1906 ... | 12,543 | 5,049 | 171,994 | 21,772 | 168 | 11,564 | 54,557 | 1,578 | 35,829 |
| 1907 ... | 13,314 | 5,210 | 173,638 | 20,254 | 146 | 12,668 | 128,344 | 2,590 | 24,183 |
| 1908 ... | 13,009 | 4,887 | 174,345 | 25,048 | 127 | 10,643 | 181,975 | 6,055 | 16,384 |
| 1909 ... | 13,797 | 6,283 | 216,286 | 27,095 | 122 | 12,498 | 201,393 | 9,140 | 11,564 |
| 1910 ... | 13,099 | 6,329 | 266,783 | 29,094 | 124 | 14,728 | 273,614 | 7,643 | 9,871 |
| 1911 ... | 14,584 | 6,554 | 329,751 | 28,921 | 133 | 16,430 | 392,129 | 22,075 | 11,015 |
| 1912 ... | 12,940 | 6,682 | 286,528 | 26,410 | 141 | 14,197 | 48,540 | 21,514 | 57,668 |

| Year. | Quicksilver. | Salt. | Slag and Slag Wool. | Sodium Salts. | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Bicarbonate. | Carbonate. | Hydroxide. | Nitrate. (Chile Saltpeter.) | Soda, Calcined. | Sulphate and Sulphite. |
| 1900... | 23 | 236,291 | 32,494 | 1,314 | 1,392 | 1,913 | 14,159 | 44,316 | 41,572 |
| 1901... | 27 | 286,424 | 27,269 | 1,086 | 1,382 | 4,926 | 13,481 | 45,967 | 45,462 |
| 1902... | 109 | 328,324 | 22,726 | 954 | 2,449 | 5,650 | 14,737 | 33,109 | 56,748 |
| 1903... | 62 | 399,184 | 14,674 | 1,016 | 2,982 | 5,886 | 17,583 | 46,086 | 47,660 |
| 1904... | 43 | 347,351 | 38,587 | 1,524 | 3,050 | 5,084 | 21,075 | 43,590 | 45,506 |
| 1905... | 48 | 284,203 | 28,032 | 1,881 | 4,113 | 5,925 | 20,531 | 46,768 | 54,377 |
| 1906... | 21 | 97,878 | 49,912 | 2,120 | 5,860 | 6,101 | 22,099 | 41,598 | 64,217 |
| 1907... | 26 | 92,288 | 46,680 | 1,764 | 2,680 | 7,462 | 22,715 | 36,802 | 69,231 |
| 1908... | 26 | 318,395 | 74,821 | 1,713 | 3,842 | 7,626 | 23,549 | 56,839 | 78,510 |
| 1909... | 29 | 364,107 | 61,674 | 1,292 | 2,968 | 8,314 | 28,019 | 54,493 | 74,512 |
| 1910... | 31 | 370,074 | 58,832 | 1,370 | 5,994 | 9,295 | 27,095 | 56,545 | 89,208 |
| 1911... | 36 | 374,633 | 88,423 | 1,598 | 1,782 | 10,635 | 27,937 | 60,102 | 89,110 |
| 1912... | 37 | 430,777 | 128,740 | 1,568 | 1,057 | 12,399 | 27,431 | 66,233 | 85,372 |

| Year. | Sodium and Potassium Salts. | | Stassfurt Salts. | Strontium. | | Sulphur. | Sulphuric Acid. |
|---|---|---|---|---|---|---|---|
| | Chromates. | Sulphides. | | Carbonate. (n) | Salts. | | |
| 1900..... | 3,741 | 2,461 | 468,277 | 74 | 496 | 1,146 | 37,738 |
| 1901..... | 2,791 | 2,763 | 592,347 | 384 | 1,022 | 621 | 42,853 |
| 1902..... | 2,656 | 4,565 | 499,220 | 762 | 1,546 | 576 | 47,666 |
| 1903..... | 2,977 | 5,845 | 501,385 | 819 | 1,389 | 1,052 | 50,109 |
| 1904..... | 2,272 | 5,489 | 631,762 | 613 | 1,207 | 1,418 | 52,696 |
| 1905..... | 2,133 | 6,569 | 852,454 | 613 | 1,386 | 1,198 | 48,701 |
| 1906..... | 2,877 | 6,730 | 831,293 | 1,726 | 1,578 | 1,582 | 52,720 |
| 1907..... | 3,016 | 8,103 | 839,889 | 1,462 | 1,671 | 1,501 | 49,950 |
| 1908..... | 4,402 | 6,536 | 818,677 | 1,494 | 1,822 | 1,765 | 60,588 |
| 1909..... | 4,789 | 7,596 | 946,457 | 2,636 | 1,832 | 1,935 | 63,817 |
| 1910..... | 4,246 | 8,679 | 1,181,208 | 2,456 | 1,275 | 2,727 | 66,581 |
| 1911..... | 5,193 | 7,837 | 1,154,974 | 595 | ..... | 1,757 | 64,888 |
| 1912..... | 5,085 | 7,614 | 31,223 | 138 | ..... | 1,743 | 75,688 |

| Year. | Super-Phosphate. | Tin, Crude. | Zinc. | | | | Zinc-White, Zinc-Gray and Lithophone. |
|---|---|---|---|---|---|---|---|
| | | | Ore. | Spelter and Scrap. | Drawn or Rolled. | Sulphate. | |
| 1898..... | ..... | 1,121 | 25,192 | 46,334 | 18,281 | ..... | 19,489 |
| 1900..... | 77,118 | 1,626 | 34,941 | 51,899 | 16,709 | 382 | 20,729 |
| 1901..... | 79,190 | 1,683 | 14,002 | 54,490 | 16,517 | 324 | 24,201 |
| 1902..... | 77,818 | 2,271 | 46,965 | 70,292 | 17,015 | 430 | 28,400 |
| 1903..... | 99,672 | 2,581 | 40,458 | 67,057 | 15,715 | 264 | 27,527 |
| 1904..... | 129,925 | 2,965 | 40,488 | 70,063 | 17,917 | 332 | 26,898 |
| 1905..... | 115,886 | 3,259 | 38,972 | 67,675 | 18,982 | 296 | 27,877 |
| 1906..... | 104,713 | 4,845 | 42,546 | 69,142 | 17,794 | 426 | 26,296 |
| 1907..... | 115,049 | 4,244 | 34,863 | 93,649 | 21,484 | 425 | 30,453 |
| 1908..... | 125,464 | 3,707 | 39,450 | 75,290 | 18,661 | 347 | 26,372 |
| 1909..... | 168,988 | 5,431 | 51,994 | 82,225 | 18,961 | 342 | 25,970 |
| 1910..... | 211,812 | 7,530 | 59,440 | 8,803 | 26,623 | 334 | 36,350 |
| 1911..... | 221,521 | 7,582 | 48,998 | 81,042 | 36,093 | 387 | 34,419 |
| 1912..... | 271,075 | 6,366 | 50,100 | 105,276 | 26,370 | ..... | 43,849 |

(*a*) From *Statistisches Jahrbuch für das Deutsches Reich*. (*b*) Includes celestite. (*d*) Includes precipitated chalk. (*e*) Not reported. (*f*) Includes sodium cyanide. (*g*) Includes tripoli. (*h*) Includes nickel ore. (*i*) Included under chromium ore. (*k*) Included under bauxite. (*l*) Included under magnesium chloride. (*m*) Includes all alkali metals. (*n*) Includes witherite. (*o*) Under copperas.

# GREECE

The statistics of mineral production in Greece, according to the latest available reports, are summarized in the following table:

MINERAL PRODUCTION OF GREECE. (a)
(In metric tons or dollars; 1 drachma = 20 cents.)

| Year. | Chrome Ore. | Emery. | Gypsum. | Iron Ore. | Iron Ore. Manganiferous. | Lead Soft. | Lead Ore. Argentiferous. | Lead. Argentiferous. | Lead. Fume. | Lignite. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1898.. | 1,367 | 3,932 | 83 | 287,100 | 213,938 | 305 | (b) | 18,888 | 2,655 | 17,310 |
| 1899.. | 4,386 | 4,360 | 81 | 331,030 | 294,320 | 291 | (b) | 18,768 | 2,584 | 12,150 |
| 1900.. | 5,600 | 6,328 | 129 | 279,880 | 243,920 | 245 | 878 | 16,150 | 2,045 | 12,940 |
| 1901.. | 4,580 | 5,691 | 671 | 278,640 | 196,152 | (b) | (b) | 17,644 | 5,292 | 9,726 |
| 1902.. | 11,680 | 4,727 | 172 | 364,340 | 170,040 | (b) | 430 | 14,048 | 1,647 | 6,500 |
| 1903.. | 8,478 | 5,586 | 94 | 531,804 | 152,740 | (b) | (b) | 12,361 | (b) | 8,687 |
| 1904.. | 6,530 | 6,182 | 117 | 422,159 | 108,319 | (b) | (b) | 15,186 | (b) | 13,500 |
| 1905.. | 8,900 | 6,972 | 57 | 465,622 | 89,687 | (b) | (b) | 13,729 | (b) | 11,787 |
| 1906.. | 11,530 | 7,718 | 85 | 680,620 | 96,382 | (b) | (b) | 12,308 | (b) | 11,582 |
| 1907.. | 11,730 | 10,652 | 105 | 768,863 | 92,970 | (b) | (b) | 13,814 | (b) | 11,719 |
| 1908 . | 4,350 | 7,471 | 61 | 531,368 | 65,757 | (b) | (b) | 15,892 | (b) | 8,786 |
| 1909.. | 9,600 | 8,193 | 208 | 475,616 | 54,926 | (b) | (c) | 14,948 | (b) | 3,873 |
| 1910 . | 9,450 | 12,939 | 243 | 535,482 | 50,015 | (c) | 8,355 | 16,710 | (b) | 1,500 |
| 1911(g) | 4,615 | 9,843 | ..... | 500,996 | 733 | ..... | 5,602 | 14,234 | ..... | ..... |

| Year. | Magnesite. | | | Manganese Ore. | Puzzolan. | Sea Salt. | Sulphur. | Zinc Ore. | |
|---|---|---|---|---|---|---|---|---|---|
| | Crude. | Bricks. | Calcined. | | | | | Blende. | Calamine, Calcined. |
| 1898.... | 14,829 | 516 | 129 | 14,097 | 70,700 | 25,250 | 135 | 1,139 | 30,906 |
| 1899.... | 17,184 | 542 | 3,087 | 17,600 | 46,375 | 37,125 | 1,150 | 1,137 | 21,770 |
| 1900.... | 17,277 | 534 | 807 | 8,050 | 49,426 | 22,411 | 891 | (b) | 18,751 |
| 1901.... | 20,348 | 500 | 2,009 | 14,166 | 80,169 | 23,079 | 3,212 | 454 | 17,764 |
| 1902.... | 23,020 | 935 | 4,730 | 14,960 | 32,514 | 25,200 | 1,391 | (b) | 18,670 |
| 1903.... | 28,415 | (b) | (b) | 9,340 | 40,978 | 26,000 | 1,266 | (b) | 12,350 |
| 1904.... | 9,133 | (b) | (b) | 8,549 | 44,644 | 27,000 | 1,225 | (b) | 19,913 |
| 1905.... | 37,063 | (b) | (b) | 8,171 | 41,900 | 25,201 | 1,126 | (b) | 22,562 |
| 1906.... | 40,584 | (b) | (b) | 10,040 | 30,622 | 25,167 | (b) | (b) | 26,258 |
| 1907.... | 55,816 | (b) | (b) | 11,139 | 39,637 | 26,966 | (b) | (b) | 30,346 |
| 1908.... | 63,079 | (b) | (b) | 10,750 | 52,312 | 23,988 | (b) | 28,739 | 24,101 |
| 1909.... | 56,797 | 294 | 16,609 | 5,374 | 46,238 | 29,448 | (b) | 41,656 | 30,159 |
| 1910.... | 18,073 | 295 | 19,982 | 41 | 31,609 | 25,978 | (b) | (f)5,845 | 28,898 |
| 1911(g) . | 27,296 | 288 | 24,013 | 26,083 | ..... | 29,800 | (h)35,956 | 3,807 | 33,766 |

(a) Statistics up to 1903 communicated by E. Grohmann, Seriphos. Statistics for 1903 and subsequent years from *Statistique du Mouvement Minier de Grèce*. The figures represent sales or shipments. (b) Not reported. (c) No sales, but production of lead ore is reported at 240,013 tons in 1909 and 185,207 tons in 1910. (d) Contains 9 per cent. lead and 11 per cent. zinc. (f) Production in 1910 was 37,108 tons. (g) sales. (h) pyrites.

# INDIA

The official statistics of mineral production in British India are summarized in the subjoined table:

MINERAL PRODUCTION OF INDIA. (*a*)

(In metric tons or dollars; £1 = $5.)

| Year. | Amber. | Coal. | Chromite. | Diamonds Carats. | Gold. (*c*) | Graphite. | Iron Ore. | Jade. (*e*) *Cwt.* | Magnesite. |
|---|---|---|---|---|---|---|---|---|---|
| 1899... | 755 | 5,174,752 | ..... | ..... | 8,357,087 | 1,548 | (*d*)52,832 | 228 | (*b*) |
| 1900... | 515 | 6,222,591 | ..... | ..... | 9,205,518 | 1,859 | (*d*)57,912 | 142 | (*b*) |
| 1901... | 55 | 6,741,899 | ..... | ..... | 9,394,723 | 2,530 | (*d*)58,725 | 206 | (*b*) |
| 1902... | 2,160 | 7,543,272 | ..... | ..... | 9,611,985 | 4,648 | (*d*)77,273 | 174 | 3,597 |
| 1903... | 2,070 | 7,557,400 | 248 | ..... | 11,203,926 | 3,448 | (*d*)62,337 | 99 | 838 |
| 1904... | 4,190 | 8,348,561 | 3,596 | 286.5 | 11,513,340 | 2,955 | 72,757 | 130 | 1,193 |
| 1905... | 4,725 | 8,552,422 | 2,708 | 172.4 | 11,760,957 | 2,361 | 104,174 | 106 | 2,645 |
| 1906... | 3,545 | 9,939,782 | 4,375 | 305.9 | 10,852,546 | 2,642 | 75,295 | 116 | 1,861 |
| 1907... | 1,925 | 11,326,254 | 18,597 | 268.0 | 10,348,795 | 2,472 | 68,928 | 2,636 | 189 |
| 1908... | 1,820 | 12,974,588 | 4,821 | 140.8 | 10,597,404 | 2,919 | 60,175 | 3,211 | 7,655 |
| 1909... | 1,435 | 12,060,580 | 9,398 | 147.8 | 10,728,900 | 3,182 | 84,791 | 2,487 | 749 |
| 1910... | 1,415 | 12,240,775 | 1,765 | 77.7 | 10,717,300 | 4,319 | 55,499 | 1,908 | 5,265 |
| 1911... | 665 | 12,919,618 | 3,865 | 53.0 | 10,890,804 | 4,113 | 372,057 | 2,063 | 3,546 |
| 1912 (*f*). | 895 | 14,942,376 | 2,936 | 29.7 | 11,054,608 | *Nil* | 459,782 | 806 | 15,626 |

| Year. | Manganese Ore. | Mica. | Petroleum *Gallons.* | Rubies. | Salt. | Saltpeter (Potassium Nitrate.) | Tin Ore. |
|---|---|---|---|---|---|---|---|
| 1899.... | 88,524 | 497 | 32,934,007 | 454,240 | 977,269 | 18,555 | 64 |
| 1900.... | 129,865 | 1,025 | 37,729,211 | 486,630 | 1,071,877 | 20,189 | 94 |
| 1901.... | 122,831 | 1,505 | 50,075,117 | 522,380 | 1,208,933 | 17,711 | 63 |
| 1902.... | 160,311 | 806 | 56,607,688 | 434,475 | 1,116,797 | 17,320 | 91 |
| 1903.... | 174,563 | 1,002 | 87,859,069 | 444,095 | 1,021,581 | 18,711 | 100 |
| 1904.... | 152,601 | 828 | 118,491,382 | 453,060 | 1,319,535 | 14,200 | 63 |
| 1905.... | 250,788 | 1,172 | 144,798,444 | ..... | 1,426,066 | 15,745 | 68 |
| 1906.... | 579,231 | 2,458 | 140,553,122 | 465,115 | 1,371,172 | 16,822 | 87 |
| 1907.... | 916,770 | 2,652 | 152,045,677 | 491,290 | 1,120,453 | 18,664 | 77 |
| 1908.... | 685,135 | 2,720 | 176,646,320 | 239,770 | 1,390,153 | 19,620 | 96 |
| 1909.... | 652,958 | 1,672 | 233,678,087 | 293,200 | 1,275,688 | 20,953 | 86 |
| 1910.... | 813,721 | 1,153 | 214,829,647 | 294,245 | 1,720,194 | 16,140 | 90 |
| 1911.... | 681,048 | 1,722 | 225,792,094 | 337,970 | 1,495,687 | 14,910 | 99 |
| 1912.... | 647,675 | 2,217 | 249,033,518 | 347,735 | 1,331,961 | 15,036 | 381 |

(*a*) Records of the Geological Survey of India. (*b*) Not reported. (*c*) £1 = $4.866. (*d*) Production of iron ore in Bengal only. (*e*) Exports in cwt. of 112 lb. (*f*) 1912 figures provisional.

# ITALY

The following tables itemize the statistics of the production and the foreign commerce of mineral and metallurgical products in Italy:

MINERAL PRODUCTION AND REFINED PRODUCTS OF ITALY. (a)
(In metric tons or dollars; 5 lire = $1.)

| Year. | Alum. | Aluminum Sulphate. | Alunite. | Antimony. | Antimony Ore. | Asphalt, Mastic and Bitumen. | Asphaltic Rock. | Barytes. |
|---|---|---|---|---|---|---|---|---|
| 1898..... | 1,165 | 2,915 | 7,000 | 380 | 1,931 | 17,813 | 93,750 | 12,400 |
| 1899..... | 945 | 2,330 | 5,800 | 581 | 3,791 | 41,732 | 81,987 | 12,545 |
| 1900..... | 1,097 | 2,403 | 5,200 | 1,174 | 7,609 | 33,127 | 101,738 | 14,003 |
| 1901..... | 1,075 | 2,260 | 4,900 | 1,721 | 8,818 | 31,814 | 104,111 | 13,245 |
| 1902..... | ..... | ..... | 8,200 | 1,574 | 6,116 | 33,684 | 64,245 | ..... |
| 1903..... | ..... | ..... | 8,100 | 905 | 6,927 | 35,757 | 89,078 | ..... |
| 1904..... | 2,490 | 2,210 | 8,000 | 836 | 5,712 | 34,227 | 111,390 | 250 |
| 1905..... | 2,975 | 2,740 | 8,500 | 327 | 5,083 | 26,838 | 106,586 | 590 |
| 1906..... | 2,878 | 2,800 | 7,500 | 537 | 5,704 | 34,386 | 130,225 | 800 |
| 1907..... | 3,175 | 3,010 | 7,600 | 610 | 7,892 | 38,568 | 161,126 | 1,720 |
| 1908..... | 2,875 | 2,100 | 6,165 | 345 | 2,821 | 34,761 | 134,163 | 1,895 |
| 1909..... | 2,580 | 2,750 | 5,636 | 59 | 1,077 | 39,165 | 111,067 | 1,950 |
| 1910..... | 2,510 | 2,773 | 6,081 | *Nil* | 2,194 | 41,705 | 162,212 | 14,420 |
| 1911..... | 2,725 | 2,493 | 6,100 | *Nil* | 2,441 | 50,179 | 188,133 | 13,620 |
| 1912..... | 1,299 | 2,727 | 6,002 | | 1,878 | 52,747 | 181,398 | (g) 1,088 |

| Year. | Borax, Refined. | Boric Acid. | | Coal. (c) | Coal. (Briquettes.) | Coke. | Copper. | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Crude. | Refined. | | | | Ore. | Ingot, etc. | Sulphate. |
| 1898... | 702 | 2,650 | 166 | 341,327 | 594,500 | 469,228 | 95,128 | 3,230 | 6,364 |
| 1899... | 709 | 2,674 | 129 | 388,534 | 566,000 | 485,951 | 94,764 | 3,032 | 7,795 |
| 1900... | 858 | 2,491 | 283 | 479,896 | 703,740 | 487,831 | 95,644 | 2,797 | 13,191 |
| 1901... | 544 | 2,558 | 347 | 425,614 | 754,800 | 490,803 | 107,750 | 3,097 | 15,374 |
| 1902... | ..... | 2,763 | ..... | 414,569 | ..... | ..... | 101,142 | ..... | 14,601 |
| 1903... | ..... | 2,583 | ..... | 346,887 | 724,993 | 554,559 | 114,823 | ..... | 18,164 |
| 1904... | 569 | 2,624 | 314 | 362,151 | 903,610 | 607,297 | 157,503 | 2,313 | 17,237 |
| 1905... | 1,007 | 2,700 | 749 | 412,916 | 842,250 | 627,984 | 149,035 | 1,175 | 26,212 |
| 1906... | 1,062 | 2,561 | 562 | 473,293 | 829,277 | 672,689 | 147,137 | ..... | 34,270 |
| 1907... | 880 | 2,305 | 466 | 453,137 | 787,087 | 717,704 | 167,619 | 17,491 | 45,263 |
| 1908... | 1,024 | 2,520 | 429 | 480,029 | 822,699 | 813,842 | 106,629 | 18,280 | 42,598 |
| 1909... | 1,110 | 2,431 | 578 | 555,073 | 924,479 | 999,381 | 90,272 | 20,005 | 28,551 |
| 1910... | 912 | 2,502 | 695 | 562,154 | 918,055 | 1,160,543 | 68,369 | 22,467 | 36,236 |
| 1911... | 738 | 2,648 | 444 | 555,137 | 794,206 | 363,493 | 68,136 | 22,908 | 44,626 |
| 1897... | 813 | 2,309 | 760 | 663,812 | 874,365 | 437,706 | 86,001 | 12,319 | 52,312 |

| Year. | Gold. | | Graphite. | Iron and Steel. | | | | |
|---|---|---|---|---|---|---|---|---|
| | Ore. | Bullion. | | Ore. | Pig. | Bar, sheet, Pipe, Wire, etc. | Tin Plate. | Steel. |
| 1898..... | 9,549 | $ 124,869 | 6,435 | 190,110 | 12,387 | 167,499 | 7,200 | 87,467 |
| 1899..... | 11,859 | 75,294 | 9,990 | 236,549 | 19,218 | 197,730 | 8,000 | 108,501 |
| 1900..... | 5,840 | 38,212 | 9,720 | 247,278 | 23,990 | 190,518 | 10,000 | 115,887 |
| 1901..... | 890 | 2,725 | 10,313 | 232,299 | 15,819 | 180,729 | 7,550 | 123,310 |
| 1902..... | 1,215 | ..... | 9,210 | 240,705 | ..... | ..... | ..... | ..... |
| 1903..... | 5,734 | 41,933 | 7,920 | 374,790 | 90,744 | 177,392 | 11,275 | 154,134 |
| 1904..... | 6,746 | 43,063 | 9,765 | 409,460 | 112,598 | 181,385 | 16,655 | 177,086 |
| 1905..... | 1,200 | 9,169 | 10,572 | 366,616 | 181,248 | 205,915 | 18,560 | 244,793 |
| 1906..... | 6,543 | 47,321 | 10,805 | 384,217 | 180,940 | 236,946 | 16,350 | 332,924 |
| 1907..... | 13,475 | 33,582 | 10,989 | 517,952 | 148,996 | 248,157 | 24,423 | 346,749 |
| 1908..... | 14,671 | 39,930 | 12,914 | 539,120 | 158,100 | 302,509 | 28,277 | 437,674 |
| 1909..... | 2,890 | 6,562 | 11,583 | 505,095 | 254,904 | 281,098 | 35,880 | 608,795 |
| 1910..... | 2,147 | 10,047 | 12,510 | 551,259 | 399,700 | 311,210 | 42,670 | 670,983 |
| 1911..... | 2,080 | 36,550 | 12,621 | 373,786 | 302,931 | 303,223 | 25,662 | 697,958 |
| 1912..... | 2,366 | 11,440 | 13,170 | 582,066 | 379,989 | 178,216 | 28,916 | 794,770 |

| Year. | Lead. | | Manganese Ore. | Manganiferous Iron Ore. | Marble. | Petroleum. Crude. | Refined Petroleum, Benzene, etc. | Pumice-Stone. |
|---|---|---|---|---|---|---|---|---|
| | Ore. | Pig. | | | | | | |
| 1898..... | 33,930 | 24,543 | 3,002 | 11,150 | 271,725 | 2,015 | 5,040 | 2,766 |
| 1899..... | 31,046 | 20,543 | 4,356 | 29,874 | 313,744 | 2,242 | 5,384 | 7,300 |
| 1900..... | 35,103 | 23,763 | 6,014 | 26,800 | 310,336 | 1,683 | 6,077 | 7,000 |
| 1901..... | 43,449 | 25,796 | 2,181 | 24,290 | 334,146 | 2,246 | 4,211 | 8,300 |
| 1902..... | 42,330 | 26,494 | 2,477 | 23,113 | ..... | 2,633 | ..... | ..... |
| 1903..... | 42,443 | 22,126 | 1,930 | 4,735 | ..... | 2,486 | 4,577 | ..... |
| 1904..... | 42,846 | 23,475 | 2,836 | 2,836 | 390,118 | 3,543 | 6,388 | 11,600 |
| 1905..... | 39,030 | 19,077 | 5,384 | 5,384 | 389,869 | 6,122 | 9,924 | 11,300 |
| 1906..... | 40,945 | 21,268 | 3,060 | 20,500 | 430,202 | 7,452 | 10,954 | 16,366 |
| 1907..... | (*d*)43,037 | 22,978 | 3,654 | 18,874 | 434,612 | 8,326 | 10,556 | 11,500 |
| 1908..... | 46,649 | 26,003 | 2,750 | 17,812 | 425,600 | 7,088 | 10,876 | 15,000 |
| 1909..... | 37,945 | 22,133 | 4,700 | 25,830 | 391,295 | 5,895 | 11,077 | 10,000 |
| 1910..... | 36,840 | 14,495 | 4,200 | 25,700 | 427,274 | 7,069 | 12,149 | 12,900 |
| 1911..... | 39,008 | 16,684 | 3,515 | 6,482 | 497,661 | 10,390 | 15,569 | 16,430 |
| 1912..... | 41,680 | 21,450 | 2,641 | | 522,088 | 7,479 | 42,306 | 17,386 |

| Year. | Pyrites. (Cupriferous in part.) | Quicksilver. | | Salt. | | | Silver. | |
|---|---|---|---|---|---|---|---|---|
| | | Ore. | Metal. | Brine. | Rock. | Sea. | Ore. | Bullion. *Kg.* |
| 1898..... | 67,191 | 19,201 | 173 | 11,546 | 18,199 | 451,426 | 435 | 43,437 |
| 1899..... | 76,538 | 29,322 | 205 | 11,021 | 18,721 | 363,826 | 540 | 33,645 |
| 1900..... | 71,616 | 33,930 | 260 | 10,890 | 18,331 | 338,034 | 584 | 31,169 |
| 1901..... | 89,376 | 38,614 | 278 | 10,690 | 23,054 | 401,443 | 511 | 32,464 |
| 1902..... | 93,177 | 44,261 | ..... | 10,581 | 23,677 | 424,239 | 421 | ..... |
| 1903..... | 101,455 | 55,528 | 312 | 10,962 | 25,911 | 451,633 | 405 | 24,388 |
| 1904..... | 112,004 | 60,403 | 352 | 11,878 | 18,638 | 433,810 | 143 | 24,943 |
| 1905..... | 117,667 | 63,378 | 369 | 12,756 | 19,669 | 405,274 | 170 | 20,215 |
| 1906..... | 122,364 | 80,638 | 417 | 13,751 | 19,007 | 496,872 | 48 | 20,362 |
| 1907..... | 126,925 | 76,561 | 434 | 19,238 | 31,540 | 454,454 | 62 | 20,502 |
| 1908..... | 131,721 | 82,534 | 684 | 15,180 | 24,033 | 473,857 | 53 | 20,746 |
| 1909..... | 149,084 | 97,592 | 771 | 15,081 | 28,026 | 421,362 | 44 | 20,534 |
| 1910..... | 165,688 | 87,129 | 894 | 16,600 | 39,197 | 447,440 | 32 | 14,237 |
| 1911..... | 165,273 | 97,803 | 955 | 17,251 | 43,763 | 460,439 | 24 | 12,143 |
| 1912..... | 277,586 | 88,200 | 1,000 | 18,775 | 39,954 | 466,240 | 27 | 14,363 |

| Year. | Sulphur. | | | Talc. Ground. | Zinc. | |
|---|---|---|---|---|---|---|
| | Crude (Fused). | Ground. | Refined. | | Ore. | Spelter. |
| 1898..... | 502,351 | 146,001 | 99,494 | 12,760 | 132,099 | 250 |
| 1899..... | 563,697 | 161,509 | 110,213 | 11,000 | 150,629 | 251 |
| 1900..... | 544,119 | 167,466 | 157,957 | 14,415 | 139,679 | 547 |
| 1901..... | 563,096 | 171,252 | 141,431 | 11,770 | 135,784 | 511 |
| 1902..... | 510,333 | ..... | ..... | ..... | 131,965 | ..... |
| 1903..... | 553,751 | 139,376 | 139,464 | 6,300 | 157,521 | 126 |
| 1904..... | 527,563 | 189,266 | 163,695 | 6,740 | 148,365 | 189 |
| 1905..... | 568,927 | 180,676 | 180,774 | 6,626 | 147,834 | 5 |
| 1906..... | 499,814 | 176,476 | 170,990 | 7,894 | 155,751 | 69 |
| 1907..... | 426,972 | 151,338 | 160,617 | 8,850 | 160,517 | 188 |
| 1908..... | 445,312 | 160,693 | 156,995 | 9,410 | (*e*)152,254 | (*b*) |
| 1909..... | 435,060 | 132,531 | 144,579 | 9,530 | (*g*)130,890 | (*b*) |
| 1910..... | (*i*)430,366 | 171,570 | 169,093 | 11,580 | (*g*)146,307 | (*b*) |
| 1911..... | 414,671 | 176,538 | 166,802 | 14,156 | 139,719 | (*b*) |
| 1912..... | 389,451 | 164,764 | 168,514 | 12,324 | 149,776 | ..... |

(*a*) From *Rivista del Servizio Minerario.* (*b*) Not reported. (*c*) Includes anthracite, lignite, fossil wood and bituminous schist. (*d*) Does not include 680 tons lead and zinc ore. (*e*) Includes 560 tons lead-zinc ore. (*g*) Includes 290 and 300 tons lead-zinc ore,. 1909 and 1910. (*h*) Includes 19,460 from foreign ores. (*i*) Besides 21,297 tons ore sold. Natural. (*j*) Ground.

**MINERAL IMPORTS OF ITALY. (a)**

**(In metric tons or dollars; 5 lire = $1.)**

| Year. | Antimony. | Arsenic. *Kg.* | Asbestos. | Asphaltum. | Barytes. | Borax and Boric Acid. | Cement and Hydraulic Lime. | Lime. |
|---|---|---|---|---|---|---|---|---|
| 1898..... | 58 | 700 | 1,186 | 1,150 | 860 | 147 | 12,029 | 18,252 |
| 1899..... | 64 | 600 | 1,675 | 1,473 | 936 | 123 | 14,391 | 13,738 |
| 1900..... | 37 | 900 | 1,645 | 1,933 | 859 | 122 | 15,494 | 18,436 |
| 1901..... | 49 | 1,800 | 2,019 | 1,450 | 825 | 232 | 14,872 | 20,731 |
| 1902..... | 80 | 1,200 | 1,536 | 1,020 | 1,170 | 516 | 13,732 | 15,216 |
| 1903..... | 98 | 4,400 | 1,691 | 1,567 | 1,099 | 504 | 15,547 | 10,063 |
| 1904..... | 131 | 3,700 | 2,174 | 2,604 | 1,875 | 271 | 15,260 | 6,891 |
| 1905..... | 117 | 3,400 | 1,806 | 3,252 | 1,444 | 112 | 15,797 | 5,556 |
| 1906..... | 50 | 5,300 | 2,171 | 2,854 | 1,400 | 163 | 18,937 | 7,714 |
| 1907..... | 163 | 3,100 | 3,110 | 3,661 | 1,540 | 307 | 29,024 | 6,156 |
| 1908..... | 153 | 2,800 | 2,548 | 3,730 | 1,523 | 333 | 28,935 | 7,210 |
| 1909..... | 293 | 4,800 | 2,285 | 3,826 | 2,094 | 386 | 25,250 | 11,120 |
| 1910..... | 342 | 5,300 | 2,051 | 3,365 | 1,777 | 363 | 22,183 | 9,007 |
| 1911..... | 358 | 5,500 | 3,892 | 4,238 | 2,024 | 741 | 24,467 | 7,942 |
| 1912..... | 636 | 4,600 | 4,226 | 3,548 | 1,986 | 380 | 23,423 | 6,663 |

| Year. | Coal. | Copper Ore. | Copper, Cement. | Copper, Brass and Bronze. | Copper and Iron Sulphates. | Gold. *Kg.* | Graphite. |
|---|---|---|---|---|---|---|---|
| 1898..... | 4,431,524 | 5,471 | 2,040 | 7,433 | 25,560 | 507 | 382 |
| 1899..... | 4,859,556 | 2,777 | 1,328 | 7,334 | 27,408 | 326 | 608 |
| 1900..... | 4,947,180 | 5,290 | 1,298 | 9,249 | 32,127 | 309 | 982 |
| 1901..... | 4,838,994 | 11,047 | 1,987 | 8,659 | 32,058 | 494 | 102 |
| 1902..... | 5,406,069 | 9,422 | 2,299 | 10,865 | 25,107 | 479 | 60 |
| 1903..... | 5,546,823 | 9,459 | 649 | 9,588 | 24,566 | 1,396 | 63 |
| 1904..... | 5,904,578 | 8,104 | 309 | 15,198 | 37,298 | 1,961 | 52 |
| 1905..... | 6,437,539 | 6,879 | 486 | 18,188 | 30,684 | 5,768 | 107 |
| 1906..... | 7,673,435 | 9,363 | 802 | 21,458 | 25,060 | 4,571 | 361 |
| 1907..... | 8,300,439 | 18,023 | 888 | 28,937 | 15,939 | 4,443 | 267 |
| 1908..... | 8,452,320 | 14,784 | 344 | 28,025 | 25,037 | (d)8,367 | 383 |
| 1909..... | 9,303,506 | 11,303 | 630 | 22,391 | 9,137 | (d)8,311 | 141 |
| 1910..... | 9,338,752 | 7,550 | 456 | 30,339 | 13,599 | (d)13,188 | 229 |
| 1911..... | 9,595,882 | 6,607 | 277 | 38,650 | 37,929 | (d)12,712 | 246 |
| 1912..... | 10,057,228 | 6,253 | 578 | 43,729 | 36,602 | (d)10,545 | 403 |

| Year. | Iron. | | Iron and Steel Scrap. | Lead. | | Lead Oxide and Carbonate. | Mineral Paints. |
|---|---|---|---|---|---|---|---|
| | Ore. | Pig. | | Ore. (c) | Metal and Alloys in Pigs. | | |
| 1898..... | 8,723 | 169,059 | 138,426 | 10,947 | 1,431 | 647 | 692 |
| 1899..... | 20,799 | 191,613 | 245,616 | 7,476 | 3,990 | 662 | 958 |
| 1900..... | 19,205 | 160,686 | 197,415 | 9,134 | 3,248 | 557 | 958 |
| 1901..... | 4,054 | 159,972 | 148,305 | 9,063 | 2,926 | 815 | 865 |
| 1902..... | 4,314 | 155,143 | 198,914 | 1,680 | 7,563 | 846 | 670 |
| 1903..... | 5,937 | 126,756 | 206,036 | 689 | 5,398 | 768 | 859 |
| 1904..... | 4,390 | 149,130 | 246,359 | 2,187 | 4,541 | 871 | 940 |
| 1905..... | 4,745 | 136,077 | 276,311 | 465 | 6,764 | 686 | 974 |
| 1906..... | 6,452 | 168,985 | 344,977 | 4,526 | 10,958 | 984 | 964 |
| 1907..... | 22,046 | 231,042 | 362,567 | 4,342 | 9,231 | 953 | 1,119 |
| 1908..... | 31,090 | 254,239 | 326,119 | 5,620 | 11,742 | 1,474 | 2,616 |
| 1909..... | 28,150 | 246,730 | 416,354 | 3,003 | 10,011 | 1,132 | 1,713 |
| 1910..... | 17,673 | 204,854 | 386,604 | 1,426 | 14,674 | 1,225 | 1,775 |
| 1911..... | 50,554 | 234,770 | 392,703 | 6,042 | 20,187 | 1,077 | 1,756 |
| 1912..... | 18,551 | 267,480 | 343,728 | 12,391 | 15,627 | 914 | 1,962 |

| Year. | Nickel Alloys and Manufactures. | Petroleum. | Phosphate Rock. | Potash, Ammonia and Caustic Soda. | Potassium Sulphate. | Quick-Silver. | Silver, *Kg.* | Slag, Metalliferous |
|---|---|---|---|---|---|---|---|---|
| 1898..... | 258 | 70,654 | 65,126 | 11,047 | 928 | 39 | 991 | 51,199 |
| 1899..... | 250 | 71,391 | 116,283 | 12,370 | 1,297 | 62 | 1,782 | 56,549 |
| 1900..... | 232 | 73,089 | 140,281 | 14,077 | 1,670 | 49 | 2,678 | 32,254 |
| 1901..... | 476 | 69,298 | 142,108 | 14,693 | 1,411 | 36 | 4,391 | 7,312 |
| 1902..... | 561 | 68,781 | 159,341 | 17,617 | 1,566 | 57 | 8,768 | 5,634 |
| 1903..... | 525 | 68,220 | 172,328 | 17,528 | 1,353 | 28 | 12,541 | 8,849 |
| 1904..... | 652 | 69,233 | 217,162 | 14,846 | 1,663 | 25 | 15,885 | 3,821 |
| 1905..... | 574 | 66,493 | 240,144 | 17,752 | 1,804 | 57 | 20,697 | 72,785 |
| 1906..... | 717 | 64,541 | 307,762 | 16,718 | 1,534 | 12 | 20,410 | 88,118 |
| 1907..... | 725 | 72,715 | 384,896 | 15,225 | 3,866 | 11 | 21,829 | 5,378 |
| 1908..... | 1,079 | 82,373 | 531,921 | 14,962 | 4,891 | 10 | (*d*)83,434 | 1,122 |
| 1909..... | 540 | 88,929 | 478,199 | 15,547 | 5,333 | 2.2 | (*d*)47,234 | 878 |
| 1910..... | 1,311 | 84,748 | 422,714 | 16,983 | 7,753 | 2.5 | (*d*)55,516 | 3,153 |
| 1911..... | 1,584 | 119,245 | 479,042 | 16,312 | 9,493 | 2.0 | (*d*)52,576 | 95 |
| 1912..... | 1,742 | 113,231 | 466,144 | 17,816 | 13,466 | 1.5 | (*d*)79,763 | 164 |

| Year. | Sodium Salts. | | Sod. and Pot. Nitrates, Refined. | Tin. | | Zinc. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Carbonate. | Nitrate (Crude). | | Block. | Mnfres. | Ore. | Oxide. | Spelter and Old. | Mnfres. |
| 1898.... | 20,845 | 19,961 | 702 | 1,722 | 109 | 216 | 573 | 2,813 | 3,200 |
| 1899.... | 22,654 | 22,385 | 671 | 1,240 | 96 | (*b*) | 804 | 3,498 | 3,221 |
| 1900.... | 23,215 | 27,706 | 511 | 1,643 | 56 | 85 | 1,034 | 3,627 | 3,543 |
| 1901.... | 21,956 | 40,498 | 315 | 1,858 | 91 | 23 | 813 | 3,991 | 4,079 |
| 1902.... | 26,133 | 24 483 | 314 | 2,114 | 110 | 131 | 904 | 3,805 | 4,167 |
| 1903.... | 24,753 | 43,480 | 638 | 2,288 | 130 | 46 | 1,416 | 4,551 | 4,461 |
| 1904.... | 27,747 | 32,283 | 613 | 2,170 | 150 | 362 | 1,124 | 5,202 | 4,168 |
| 1905.... | 29,066 | 46,517 | 689 | 2,304 | 103 | 14 | 1,246 | 5,997 | 4,701 |
| 1906.... | 31,170 | 32,508 | 395 | 3,361 | 167 | 2,042 | 1,920 | 6,835 | 4,421 |
| 1907.... | 35,538 | 41,457 | 668 | 2,771 | 183 | 11 | 1,962 | 8,152 | 5,407 |
| 1908.... | 38,268 | 60,784 | 428 | 2,602 | 187 | 7 | 2,026 | 9,339 | 5,112 |
| 1909.... | 38,252 | 43,658 | 532 | 2,555 | 191 | 13 | 1,571 | 9,222 | 4,572 |
| 1910.... | 45,174 | 61,192 | 1,083 | 2,760 | 238 | 18 | 2,001 | 8,971 | 5,416 |
| 1911.... | 45,596 | 59,561 | 417 | 2,524 | 211 | 428 | 2,100 | 10,742 | 5,892 |
| 1912.... | 49,284 | 54,634 | 529 | 2,626 | 157 | *Nil.* | 2,550 | 11,955 | 5,833 |

## MINERAL EXPORTS OF ITALY. (*a*)

(In metric tons or dollars; 5 lire = $1.)

| Year. | Antimony. | Asbestos. | Asphaltum. | Barytes. | Borax and Boric Acid. | Cement and Hydraulic Lime. | Lime. | Coal. |
|---|---|---|---|---|---|---|---|---|
| 1898..... | 338 | 208 | 19,465 | 70 | 2,167 | 5,192 | 6,744 | 17,749 |
| 1899..... | 240 | 245 | 26,402 | 45 | 2,872 | 5,462 | 5,386 | 20,803 |
| 1900..... | 467 | 261 | 24,287 | 40 | 2,114 | 6,860 | 2,980 | 23,926 |
| 1901..... | 765 | 302 | 21,856 | 32 | 2,190 | 8,463 | 3,428 | 25,594 |
| 1902..... | 359 | 144 | 20,884 | 91 | 1,847 | 7,930 | 4,215 | 33,374 |
| 1903..... | 314 | 222 | 24,303 | 35 | 901 | 6,325 | 3,802 | 29,219 |
| 1904..... | 107 | 163 | 14,880 | 70 | 1,122 | 7,810 | 4,089 | 35,149 |
| 1905..... | 132 | 236 | 23,740 | 162 | 2,255 | 8,445 | 5,007 | 38,555 |
| 1906..... | 208 | 205 | 27,176 | 147 | 2,777 | 6,774 | 4,194 | 31,666 |
| 1907..... | 115 | 142 | 26,036 | 152 | 1,330 | 4,477 | 3,118 | 40,769 |
| 1908..... | 10 | 193 | 24,158 | 724 | 1,005 | 5,439 | 3,224 | 46,774 |
| 1909..... | 8 | 527 | 21,978 | 125 | 1,704 | 7,534 | 2,533 | 51,343 |
| 1910..... | 2 | 485 | 26,125 | 150 | 1,536 | 7,131 | 3,525 | 48,144 |
| 1911..... | *Nil.* | 517 | 28,455 | 353 | 1,347 | 10,742 | 5,764 | 40,800 |
| 1912 .... | 11 | 571 | 13,158 | 381 | 1,661 | 55,091 | 9,440 | 26,298 |

| Year. | Copper. Ore. | Copper and Iron Sulphate. | Gold. *Kg.* | Graphite. | Iron. | | |
|---|---|---|---|---|---|---|---|
| | | | | | Ore. | Pig. | Scrap. |
| 1898 | 2,356 | 25 | 1,739 | 5,145 | 217,556 | 840 | ..... |
| 1899 | 1,148 | 20 | 1,162 | 8,114 | 234,515 | 378 | ..... |
| 1900 | 1,179 | 60 | 2,763 | 7,820 | 170,286 | 329 | ..... |
| 1901 | 9 | 20 | 2,955 | 7,169 | 121,592 | 311 | ..... |
| 1902 | 11 | 39 | 733 | 7,098 | 209,070 | 395 | ..... |
| 1903 | 15 | 44 | 1,291 | 7,068 | 98,319 | 810 | ..... |
| 1904 | 43 | 29 | 1,494 | 7,433 | 2,577 | 229 | ..... |
| 1905 | 77 | 249 | 1,731 | 6,811 | 11,358 | 1,395 | ..... |
| 1906 | 189 | 102 | 1,476 | 4,904 | 1,833 | 254 | ..... |
| 1907 | 179 | 835 | 802 | 7,474 | 26,000 | 121 | ..... |
| 1908 | 188 | 721 | 7,588 | 7,009 | 35,653 | 176 | 1,676 |
| 1909 | 233 | 1,211 | 15,452 | 8,125 | 46 | 209 | 1,480 |
| 1910 | 969 | 741 | 16,643 | 7,647 | 9,892 | 327 | 2,450 |
| 1911 | 130 | 157 | 14,144 | 7,633 | 22,851 | 290 | 3,390 |
| 1912 | 288 | 1,445 | 13,933 | 7,785 | 12,313 | 51 | 5,627 |

| Year. | Lead. | | | Mineral Paints. | Phosphate Rock. | Quick-Silver. | Salt. | Silver, *Kg.* |
|---|---|---|---|---|---|---|---|---|
| | Ore. | Lead Alloys in Pigs. | Oxide and Carbonate. | | | | | |
| 1898 | 4,492 | 5,870 | 414 | 2,884 | (*b*) | 244 | 126,860 | 68,607 |
| 1899 | 3,129 | 2,497 | 389 | 2,784 | (*b*) | 223 | 114,050 | 32,432 |
| 1900 | 3,741 | 5,018 | 367 | 2,977 | 1,726 | 259 | 112,900 | 25,310 |
| 1901 | 3,977 | 4,463 | 410 | 2,913 | 1,290 | 301 | 114,210 | 42,325 |
| 1902 | 3,354 | 5,650 | 404 | 2,953 | 894 | 215 | 145,190 | 20,427 |
| 1903 | 5,041 | 2,911 | 426 | 3,305 | 2,942 | 222 | 144,910 | 9,486 |
| 1904 | 5,524 | 1,954 | 347 | 3,231 | 2,812 | 266 | 130,940 | 24,165 |
| 1905 | 4,311 | 976 | 310 | 3,632 | 3,519 | 243 | 116,040 | 25,947 |
| 1906 | 8,356 | 2,005 | 315 | 4,502 | 1,652 | 278 | 126,199 | 18,262 |
| 1907 | 3,213 | 1,548 | 240 | 4,602 | 4,560 | 350 | 99,191 | 18,164 |
| 1908 | 2,041 | 1,243 | 219 | 3,446 | 2,271 | 565 | 85,489 | (*d*)28,716 |
| 1909 | 1,037 | 782 | 211 | 4,310 | 2,979 | 714 | 103,895 | (*d*)87,653 |
| 1910 | 4,122 | 933 | 197 | 3,945 | 3,627 | 781 | 122,404 | (*d*)22,403 |
| 1911 | 15,791 | 637 | 196 | 4,182 | 5,427 | 1,037 | 119,173 | (*d*)28,434 |
| 1912 | 17,062 | 4,122 | 75 | 4,417 | 1,285 | 993 | 155,543 | (*d*)27,275 |

| Year. | Slag. | Sodium Salts. | | | Sulphur. | Tin. | | Zinc. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Carbonate | Nitrate. (Crude.) | Sod. and Pot. Nitrates, Refined. | | Block. | Manufactures | Ore. | Oxide. | Spelter and Scrap. |
| 1898 | 6,861 | 391 | 79 | 256 | 405,823 | 34 | 177 | 130,064 | 110 | 156 |
| 1899 | 4,898 | 438 | 136 | 124 | 424,018 | 69 | 176 | 140,107 | 123 | 227 |
| 1900 | 4,222 | 486 | 58 | 129 | 479,139 | 147 | 153 | 111,870 | 102 | 359 |
| 1901 | 3,261 | 377 | 116 | 59 | 414,018 | 202 | 187 | 103,020 | 140 | 349 |
| 1902 | 3,615 | 446 | 346 | 259 | 439,242 | 236 | 174 | 114,894 | 122 | 338 |
| 1903 | 4,929 | 482 | 781 | 492 | 461,289 | 173 | 180 | 116,449 | 116 | 591 |
| 1904 | 4,458 | 376 | 363 | 230 | 437,067 | 171 | 151 | 126,393 | 483 | 263 |
| 1905 | 9,844 | 214 | 424 | 159 | 381,128 | 285 | 107 | 117,810 | 173 | 434 |
| 1906 | 8,990 | 253 | 80 | 133 | 336,339 | 303 | 81 | 144,244 | 687 | 639 |
| 1907 | 10,934 | 200 | 138 | 102 | 297,378 | 434 | 117 | 142,271 | 727 | 1,182 |
| 1908 | 12,122 | 583 | 37 | 57 | 330,093 | 180 | 173 | 122,456 | 395 | 984 |
| 1909 | 17,163 | 517 | 464 | 163 | 329,233 | 85 | 126 | 123,936 | 212 | 983 |
| 1910 | 10,488 | 321 | 98 | 45 | 344,513 | 164 | 245 | 127,315 | 957 | 845 |
| 1911 | 8,274 | 180 | 168 | 15 | 398,592 | 166 | 319 | 133,471 | 1,577 | 616 |
| 1912 | 19,594 | 243 | 27 | 7 | 376,387 | 83 | 359 | 152,840 | 2,165 | 1,222 |

(*a*) From *Statistica del Commercio speciale di Importazione e di Esportazione.* (*b*) Not reported. (*c*) Includes argentiferous lead ore. (*d*) Includes coin, bullion, sheets, and leaf.

# JAPAN

The total mineral production of the Japanese Empire, according to the latest available returns, is shown in the following table, in metric tons, unless otherwise specified:

MINERAL PRODUCTION OF JAPAN. (a).

| Year. | Antimony. | | Arsenic. *Kg.* | Coal. | Copper. | Gold. *Kg.* | Graphite | Iron. Pig. | Lead. |
|---|---|---|---|---|---|---|---|---|---|
| | Ore. | Metal. | | | | | | | |
| 1896.... | 828 | 517 | 6,043 | 5,100,005 | 20,114 | 964 | 215 | 27,420 | 1,958 |
| 1897.... | 348 | 823 | 13,039 | 5,147,103 | 20,425 | 1,037 | 391 | 28,040 | 1,737 |
| 1898.... | 1,005 | 235 | 7,129 | 6,643,047 | 21,023 | 1,159 | 347 | 23,611 | 1,703 |
| 1899.... | 712 | 229 | 5,077 | 6,668,608 | 19,421 | 1,675 | 53 | 23,066 | 1,963 |
| 1900.... | 81 | 349 | 4,669 | 7,370,667 | 24,317 | 2,124 | 94 | 24,841 | 1,878 |
| 1901.... | 118 | 429 | 10,312 | 8,884,812 | 27,392 | 2,475 | 88 | 29,449 | 1,803 |
| 1902.... | 88 | 528 | 12,188 | 9,588,910 | 29,034 | 2,975 | 97 | 32,130 | 1,644 |
| 1903.... | 153 | 434 | 6,000 | 10,088,845 | 33,245 | 3,140 | 114 | 33,870 | 1,728 |
| 1904.... | 104 | 321 | 4,000 | 10,723,796 | 33,187 | 2,765 | 216 | 38,143 | 1,803 |
| 1905.... | 96 | 190 | 8,333 | 11,955,946 | 35,944 | 3,048 | 209 | 53,210 | 2,272 |
| 1906.... | 97 | 627 | 5,250 | 13,468,529 | 36,963 | 2,873 | 177 | 57,373 | 4,305 |
| 1907(*d*) . | (*b*) | 248 | 7,491 | 13,764,731 | 40,183 | 2,938 | 103 | 44,447 | 3,079 |
| 1908(*d*) . | (*b*) | 198 | 19,838 | 14,767,638 | 41,399 | 3,598 | 177 | 42,007 | 2,910 |
| 1909.... | 10 | 157 | 8,061 | 14,810,412 | 45,117 | 3,932 | 121 | 46,627 | 3,337 |
| 1910.... | 8 | 120 | 11,463 | 15,433,621 | 48,545 | 4,368 | 145 | 58,043 | 3,845 |
| 1911.... | ..... | 97 | 5,760 | 17,632,710 | 53,401 | 4,690 | 114 | 63,986 | 4,125 |

| Year. | Manganese. Ore. | Petroleum. *Gallons.* | Phosphates. | Pyrite. | Quicksilver. *Kg.* | Salt. *Hectoliters.* | Silver. *Kg.* | Sulphur. | Tin. |
|---|---|---|---|---|---|---|---|---|---|
| 1896.... | 17,967 | (*c*)7,440,206 | (*b*) | (*b*) | 1,762 | (*b*) | 64,303 | 12,540 | 50.0 |
| 1897.... | 15,448 | 9,179,474 | (*b*) | 7,626 | 2,678 | (*b*) | 54,289 | 13,582 | 47.6 |
| 1898.... | 11,497 | 11,145,457 | (*b*) | 8,726 | 1,399 | 11,482,422 | 60,436 | 10,321 | 42.7 |
| 1899.... | 11,336 | 18,844,034 | (*b*) | 8,376 | ..... | 10,483,082 | 56,161 | 10,237 | 18.5 |
| 1900.... | 15,831 | 30,470,068 | (*b*) | 16,166 | 270 | 11,890,361 | 58,799 | 14,439 | 12.3 |
| 1901.... | 16,270 | 39,056,820 | (*b*) | 17,589 | 750 | 12,463,771 | 54,739 | 16,548 | 14.1 |
| 1902.... | 10,844 | 34,850,129 | 196 | 18,580 | 1,418 | 11,042,192 | 57,635 | 18,287 | 18.6 |
| 1903.... | 5,616 | 50,724,174 | 191 | 16,149 | 206 | 6,574,890 | 58,704 | 22,914 | 19.0 |
| 1904.... | 4,324 | 51,573,754 | 13 | 24,886 | *Nil.* | 7,019,650 | 61,339 | 25,587 | 25.0 |
| 1905.... | 14,017 | 47,132,800 | 1,519 | 25,569 | 349 | (*b*) | 82,886 | 24,652 | 26.0 |
| 1906.... | 54,339 | 60,005,957 | 3,037 | 36,038 | 336 | (*b*) | 76,247 | 27,589 | 77.0 |
| 1907(*d*) . | 20,586 | 60,110,558 | 1,721 | 56,166 | 456 | (*f*)636,168 | 95,600 | 33,329 | 31.8 |
| 1908(*d*) . | 11,130 | 65,165,860 | 740 | 33,867 | 804 | (*f*)659,202 | 123,180 | 33,149 | 25.7 |
| 1909.... | 8,708 | 65,789,858 | 3,781 | 27,066 | 335 | (*f*)696,049 | 127,917 | 36,317 | 22.8 |
| 1910.... | 11,120 | 63,843,601 | 1,042 | 78,418 | 407 | (*f*)696,474 | 141,613 | 43,155 | 23. |
| 1911.... | 9,787 | 72,839,260 | 2,271 | 73,879 | 1,021 | (*g*)567,715 | 138,287 | 50,274 | 24.8 |

(*a*) From *Résumé Statistique de l'Empire du Japon*, Tokio. (*b*) Not reported. (*c*) Crude petroeum. (*d*) From reports of the Japanese Department of Agriculture and Commerce. (*e*) 328 tons of ore reported, in addition. (*f*) Metric tons including Taiwan, fiscal years. (*g*) Metric tons; from *Résumé Statistique de l'Empire du Japan.*

# MEXICO

Owing to the incompleteness of the Mexican statistics of production, we are unable to give any satisfactory table. Exports may, however, be taken as indicating the condition of the mining industry. We owe the statistics for 1908, 1909 and 1910 together with a complete revision of this table, to the courtesy of Don Miguel M. Irigoyen, chief of the Section of Statistics, Secretaria de Hacienda y Credito Publico.

MINERAL EXPORTS OF MEXICO. (a)
(In metric tons or Mexican dollars.)

| Year. | Antimony. | | Coal. | Copper. | | Gold. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Metal. | Ore. | | Ore. | Ingot. | Ore. | Bullion. | Specie. | Cyanide. | Sulphide. |
| 1897.... | ..... | 5,873 | 105,298 | 1,094 | 16,858 | $365,226 | $6,220,765 | $202,223 | $226,986 | $33,916 |
| 1898.... | ..... | 5,932 | 118,553 | 13,146 | 10,362 | 1,037,202 | 6,493,735 | 367,704 | 294,730 | 64,061 |
| 1899.... | ..... | 10,382 | 113,192 | 223 | 25,293 | 335,849 | 7,017,286 | 183,474 | 115,961 | 266,782 |
| 1900.... | ..... | 2,313 | 38,676 | 408 | 27,970 | 306,392 | 7,435,864 | 192,456 | 128,675 | 177,193 |
| 1901.... | ..... | 5,103 | 17,281 | 5,576 | 33,818 | 284,722 | 8,324,681 | 210,431 | 178,803 | 81,744 |
| 1902.... | 1,218 | 1,280 | 3,406 | 6,101 | 63,609 | 303,979 | 9,079,371 | 129,899 | 78,295 | 40,658 |
| 1903.... | 2,304 | 7,302 | 1,840 | 10,912 | 51,716 | 264,503 | 9,693,692 | 54,636 | 85,465 | 124,020 |
| 1904.... | 1,694 | 81 | 125 | 48,365 | 57,338 | 537,290 | 10,867,272 | 172,532 | 79,129 | 176,090 |
| 1905 (c). | 1,978 | 57 | 497 | 92,540 | 56,634 | 1,513,344 | 29,636,117 | 106,470 | 397,814 | 138,033 |
| 1906.... | 2,418 | 178 | 91 | 73,193 | 46,767 | 5,369,173 | 21,072,014 | 37,746 | 337,294 | 180,348 |
| 1907.... | 4,615 | 681 | 1,532 | 115,245 | 51,519 | 3,033,090 | 19,653,362 | 5,023,404 | 417,162 | 497,893 |
| 1908.... | 4,046 | 36 | 719 | 70,900 | 26,214 | 2,746,289 | 30,101,546 | 42,389 | 144,959 | 334,944 |
| 1909.... | 4,115 | 31 | 235 | 136,031 | 32,580 | 2,346,279 | 40,725,976 | 23,678 | 85,110 | 250,741 |
| 1910.... | 3,730 | 6 | 120 | 129,568 | 54,061 | 2,526,444 | 46,189,613 | 37,723 | 46,803 | 168,162 |
| 1911.... | 4,131 | 121 | 101 | 109,627 | 60,493 | 1,945,660 | 48,113,427 | 8,153,293 | 38,031 | 141,640 |
| 1912.... | 3,491 | 15 | 50,777 | 103,129 | 60,439 | 1,121,333 | 42,686,667 | 1,479,292 | 43,481 | 119,357 |

| Year. | Graphite. | Gypsum. | Lead. | | Silver. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ore. | Base Bullion. | Ore. | Bullion. | Specie. | Sulphide. | Cyanide. | Slag. |
| 1897... | 759 | 2,095 | 2 | 60,029 | $11,401,176 | $35,775,125 | $21,925,347 | $1,663,581 | $123,246 | $39,800 |
| 1898... | 1,365 | 1,650 | (b) | 60,918 | 11,048,358 | 37,137,599 | 16,588,789 | 1,663,501 | 257,342 | 46,488 |
| 1899... | 2,305 | 1,050 | 1 | 67,441 | 10,766,099 | 37,585,911 | 5,580,834 | 1,929,085 | 76,942 | 4,819 |
| 1900... | 2,561 | 1,600 | 468 | 74,944 | 12,495,524 | 41,468,745 | 22,679,655 | 1,893,646 | 67,607 | 87,880 |
| 1901... | 762 | 800 | (b) | 79,097 | 9,615,939 | 36,348,374 | 12,038,158 | 2,141,685 | 259,282 | 93,543 |
| 1902... | 1,434 | (b) | 118 | 107,366 | 4,108,088 | 45,796,576 | 17,753,526 | 1,978,919 | 108,344 | 132,093 |
| 1903... | 1,404 | (b) | 11 | 100,532 | 11,781,048 | 48,276,797 | 16,167,673 | 1,642,627 | 135,561 | 289,900 |
| 1904... | 970 | (b) | 1 | 95,010 | 11,000,869 | 45,430,020 | 7,251,132 | 1,392,356 | 171,452 | 202,594 |
| 1905 (c) | 970 | 27 | 1 | 101,196 | 8,505,834 | 63,564,789 | 20,335,297 | 736,228 | 438,094 | 29,012 |
| 1906... | 3,915 | (b) | (b) | 73,699 | 9,619,763 | 63,057,152 | 42,390,357 | 595,112 | 434,885 | (b) |
| 1907... | 3,202 | (b) | 11 | 76,158 | 11,396,844 | 68,187,169 | 23,848,571 | 785,116 | 483,638 | (b) |
| 1908... | 1,076 | (b) | 26 | 127,010 | 11,230,372 | 63,298,659 | 60,405 | 791,698 | 68,849 | (b) |
| 1909... | 1,704 | (b) | 1 | 118,186 | 8,057,189 | 66,789,716 | 91,006 | 557,520 | 78,688 | (b) |
| 1910... | 2,332 | 1 | 355 | 120,662 | 6,793,896 | 70,272,894 | 72,891 | 208,300 | 52,053 | (b) |
| 1911... | 2,974 | (b) | 397 | 124,605 | 6,766,644 | 78,515,378 | 8,901 | 235,410 | 159,170 | *None* |
| 1912... | 2,865 | (b) | 59 | 109,717 | 5,769,575 | 82,047,500 | 8,645 | (d) | 347,277 | *None* |

(a) From the *Estadistica Fiscal*. The figures for the calendar years were arrived at by combining those of the successive semesters of the different fiscal years. (b) Not reported. (c) Figures for 1904 are from *Anuario Estadistico de la República Mexicana* for 1904. (d) 11 metric tons.

# NORWAY

The official statistics of mineral production, imports and exports, are summarized in the following tables:

MINERAL PRODUCTION OF NORWAY. (*a*)
(In metric tons or dollars; 1 Krone = 27 cents.)

| Year. | Apatite. (*b*) | Chrome Ore. | Copper. | | Feldspar. | Gold. | Iron. | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Ore. | Ingot. | | | Ore. | Pig and Cast. | Bars and Steel. |
| 1900 ... | 300 | 165 | 46,588 | 1,280 | 17,609 | $2,430 | 17,925 | 444 | 614 |
| 1901 ... | 738 | 85 | 40,726 | 1,073 | 18,323 | 2,700 | 42,252 | 261 | 376 |
| 1902 ... | 2,295 | 22 | 40,499 | 1,347 | 19,591 | 36,990 | 53,675 | 527 | 461 |
| 1903 ... | 1,795 | *Nil.* | 35,417 | 1,382 | 18,590 | 8,370 | 53,475 | 509 | 442 |
| 1904 ... | 1,456 | 154 | 36,891 | 1,342 | 20,835 | *Nil.* | 45,328 | 350 | 395 |
| 1905. .. | 2,522 | *Nil.* | 37,045 | 1,153 | 22,508 | *Nil.* | 46,582 | 474 | 253 |
| 1906 ... | 3,482 | *Nil.* | 32,203 | 1,333 | 23,896 | 5,400 | 109,259 | 257 | 317 |
| 1907. .. | 1,830 | 107 | 39,887 | 1,517 | 32,970 | *Nil.* | 140,804 | *Nil.* | 283 |
| 1908 ... | 1,771 | *Nil.* | 33,688 | 1,806 | 34,437 | *Nil.* | 119,656 | ..... | ..... |
| 1909 ... | 1,364 | *Nil.* | 42,612 | 1,594 | 36,439 | 8,000 | 40,389 | ..... | ..... |
| 1910 ... | 703 | ..... | 46,308 | 1,814 | 39,507 | 5,000 | 102,447 | ..... | ..... |
| 1911 ... | 897 | ..... | 34,705 | 1,650 | 34,864 | ..... | 220,524 | 316 | ..... |
| 1912 ... | ..... | ..... | ..... | 2,150 | 35,000 | ..... | ..... | ..... | ..... |

| Year | Molybdenite. | Nickel. | | Pyrites, Iron, and Copper. | Rutile. | Silver. | | Zinc Ore. (*c*) |
|---|---|---|---|---|---|---|---|---|
| | | Ore. | Metal. | | | Ore and Native Silver. | Metal. *Kg.* | |
| 1900..... | ..... | 1,888 | 13 | 98,945 | 40 | 475 | 4,600 | 204 |
| 1901..... | ..... | 2,018 | 40 | 101,894 | 55 | 519 | 5,680 | 90 |
| 1902..... | 20 | 4,040 | 60 | 121,247 | *Nil.* | 471 | 6,220 | 30 |
| 1903..... | 31 | 5,670 | 75 | 129,939 | 25 | 481 | 7,269 | 335 |
| 1904..... | 30 | 5,352 | 73 | 133,603 | 25 | 1,297 | 8,064 | 42 |
| 1905..... | 46 | 5,477 | 77 | 162,012 | 35 | 1,570 | 7,100 | 4,241 |
| 1906..... | 1,026 | 6,081 | 81 | 197,886 | 55 | 1,565 | 6,370 | 3,308 |
| 1907..... | 30 | 5,781 | 81 | 236,038 | 55 | 1,756 | 6,700 | 400 |
| 1908..... | 35 | 5,190 | 62 | 269,129 | 83 | 2,262 | 7,470 | 2,435 |
| 1909..... | 30 | 5,770 | 69.8 | 282,606 | ..... | 2,729 | 7,780 | 983 |
| 1910..... | ..... | 19,639 | 172 | 329,642 | 116 | ..... | ..... | 2,219 |
| 1911..... | 2 | 27,743 | 488 | 369,055 | 76 | 2,892 | 7,635 | 2,240 |
| 1912..... | ..... | ..... | ..... | 430,000 | ..... | ..... | ..... | ..... |

(*a*) *Tabeller vedkommende Norges Bergværksdrift, Statistisk Aarbok for Kongeriket Norge.* (*b*) Exports which represent production. (*c*) Includes lead ore.

**MINERAL IMPORTS OF NORWAY. (a)**

**(In metric tons.)**

| Year. | Borax. *Kg.* | Cement and Hydraulic Lime. | Coke, Coal and Cinders. *Hectoliters.* | Copper and Brass. | | Iron and Steel. | |
|---|---|---|---|---|---|---|---|
| | | | | Plates and Bars. | Wares. | Pig. | Bars, Hoops, etc. Wrought Iron. |
| 1899..... | 62,060 | 33,652 | 18,475,996 | 1,000 | 1,120 | 21,445 | 25,379 |
| 1900..... | 71,124 | 24,511 | 19,002,026 | 696 | 1,164 | 20,844 | 23,010 |
| 1901..... | 68,000 | 20,993 | 17,665,349 | 1,018 | 761 | 19,112 | 20,672 |
| 1902..... | (c) | 18,984 | 19,338,615 | 1,118 | (C) | 18,969 | 26,685 |
| 1903..... | (c) | 17,906 | 20,086,974 | 899 | 309 | 20,652 | 21,977 |
| 1904..... | 54,953 | 12,845 | 21,049,128 | 688 | 866 | 18,891 | 24,094 |
| 1905..... | (c) | 13,797 | 20,973,608 | 882 | 1,146 | 20,828 | 27,740 |
| 1906..... | 63,000 | 11,676 | 21,478,000 | 906 | 783 | 20,197 | 26,015 |
| 1907..... | 79,810 | 16,647 | 24,274,260 | 954 | 1,107 | 23,345 | 32,764 |
| 1908..... | 87,255 | 44,991 | (c)2,073,907 | 1,013 | 1,157 | 26,106 | 31,849 |
| 1909 ..... | 79,786 | 57,768 | (c)2,095,611 | 869 | 1,095 | 23,167 | 31,215 |
| 1910..... | 105,453 | 20,100 | (c)2,159,717 | 1,118 | 1,406 | 28,034 | 34,623 |
| 1911..... | 100,493 | 17,892 | 2,187,246 | 1,229 | 1,780 | 26,569 | 36,172 |

| Year. | Iron and Steel—Continued. | | | | | | Lead in Pigs and Sheets. |
|---|---|---|---|---|---|---|---|
| | Anchors, Cables and Chains. | Rails. | Nails, Spikes and Screws. | Steel. | Sheets and Plates. | Other Manufactures. | |
| 1899 ..... | 1,394 | 8,137 | 1,529 | 2,652 | 32,192 | 21,400 | 869 |
| 1900 ..... | 1,203 | 11,952 | 1,219 | 2,085 | 29,318 | 17,493 | 670 |
| 1901 ..... | 1,708 | 22,959 | 1,808 | 1,905 | 31,184 | 18,372 | 590 |
| 1902 ..... | 2,103 | 15,316 | 2,205 | 1,754 | 36,288 | 22,069 | (c) |
| 1903 ..... | 1,807 | 4,631 | 1,261 | 1,958 | 42,098 | 18,855 | 311 |
| 1904 ..... | 2,109 | 5,814 | 1,071 | 1,610 | 42,013 | 5,462 | 498 |
| 1905 ..... | 2,224 | 6,566 | 1,222 | 1,436 | 42,203 | 44,414 | 448 |
| 1906..... | 2,585 | 8,086 | 1,012 | 2,018 | 48,969 | 45,959 | 727 |
| 1907 ..... | 2,653 | 6,989 | 991 | 1,592 | 47,758 | 48,965 | 887 |
| 1908 ..... | 2,535 | 12,180 | 1,032 | 1,628 | 49,569 | 52,594 | 529 |
| 1909 ..... | 1,750 | 9,051 | 1,049 | 1,911 | 46,195 | 55,198 | 536 |
| 1910 ..... | 2,131 | 5,512 | 852 | 3,203 | 56,898 | 60,282 | 838 |
| 1911 ..... | 2,327 | 15,312 | 1,129 | 3,908 | 65,847 | 72,170 | 939 |

| Year. | Lead White and Zinc Oxide. | Petroleum and Paraffin | Potash. | Salt. | Salt-peter. | Soda. | Sulphur. (b) | Tin in Blocks, etc. | Zinc in Bars, Plates, etc. |
|---|---|---|---|---|---|---|---|---|---|
| 1899 ... | 1,296 | 42,182 | 802 | 134,583 | 278 | 4,555 | 10,734 | 546 | 1,509 |
| 1900 ... | 1,216 | 39,657 | 638 | 143,365 | 356 | 4,576 | 14,827 | 149 | 1,254 |
| 1901 ... | 1,321 | 47,011 | 518 | 127,607 | 208 | 5,220 | 11,149 | 141 | 1,027 |
| 1902 ... | (c) | (c) | (c) | 141,415 | 315 | (c) | (c) | (c) | 1,104 |
| 1903 ... | (c) | 58,822 | 457 | 143,110 | 245 | 4,200 | 8,829 | 106 | 1,015 |
| 1904 ... | 1,898 | 50,543 | 477 | 153,699 | 321 | 3,197 | 12,181 | 176 | 940 |
| 1905 ... | 1,309 | 43,860 | 393 | 137,800 | 1,048 | 3,704 | 10,240 | 134 | 967 |
| 1906 ... | 1,149 | 41,546 | 396 | 167,300 | 776 | 4,334 | 11,465 | 261 | 2,791 |
| 1907 ... | 1,245 | 44,231 | 588 | 163,458 | 1,004 | 5,819 | 11,412 | 332 | 3,549 |
| 1908 ... | 1,201 | 64,680 | 504 | 177,349 | 935 | 7,850 | 12,281 | 323 | 1,418 |
| 1909 ... | 1,304 | 63,042 | 475 | 164,195 | 572 | 8,357 | 10,293 | 280 | 1,336 |
| 1910 ... | 1,277 | 63,976 | 536 | 182,288 | 546 | 9,270 | 10,279 | 358 | 5,891 |
| 1911 ... | 1,465 | 71,496 | 524 | 192,354 | 786 | 9,566 | 8,782 | 353 | 9,173 |

MINERAL EXPORTS OF NORWAY. (a)
(In metric tons.)

| Year. | Apatite. | Copper. | | | Feldspar. | Iodine. *Kg.* | Iron. |
|---|---|---|---|---|---|---|---|
| | | Ore. | Ingot. | Scrap. | | | Ore. |
| 1899 | 1,500 | 7,198 | 1,785 | 1,038 | 19,260 | 16,180 | 12,517 |
| 1900 | 300 | 5,756 | 1,891 | 1,168 | 17,609 | 11,210 | 27,158 |
| 1901 | 738 | 6,041 | 1,465 | 774 | (*d*)18,423 | 10,000 | 39,173 |
| 1902 | 2,295 | 4,848 | 1,913 | (*c*) | (*d*)19,611 | ..... | 48,775 |
| 1903 | 1,795 | 3,448 | 1,930 | 888 | (*d*)18,640 | 11,417 | 41,575 |
| 1904 | 1,456 | 2,673 | 1,124 | 785 | 20,835 | 9,414 | 45,434 |
| 1905 | 2,522 | 3,393 | 958 | 968 | 20,696 | 12,000 | 60,558 |
| 1906 | 3,482 | 84 | 875 | 964 | 19,669 | 13,248 | 81,398 |
| 1907 | 1,830 | 1,581 | 1,033 | 1,644 | 29,399 | 13,780 | 132,593 |
| 1908 | 1,771 | 156 | 1,260 | 385 | 29,896 | 11,097 | 110,425 |
| 1909 | 1,365 | 3,245 | 1,335 | 543 | 33,692 | 13,620 | 38,933 |
| 1910 | 703 | 241 | 1,377 | 583 | 39,507 | 13,114 | 88,715 |
| 1911 | 500 | 924 | 1,091 | 575 | 34,864 | 16,982 | 180,932 |

| Year. | Iron—Continued. | | | | Nickel Ore. | Pyrites. | Silver Ore. |
|---|---|---|---|---|---|---|---|
| | Pig and Scrap. | Bars and Hoops. | Nails and Spikes. | Steel. | | | |
| 1899 | 6,085 | 337 | 6,089 | 377 | 63 | 83,912 | 14 |
| 1900 | 8,141 | 135 | 5,643 | 220 | 272 | 84,604 | 90 |
| 1901 | 3,250 | 370 | 6,001 | 179 | 55 | 104,151 | 6 |
| 1902 | 7,359 | 166 | 6,431 | 240 | 1 | 105,980 | *Nil.* |
| 1903 | 6,350 | 10 | 6,504 | 200 | *Nil.* | 118,148 | *Nil.* |
| 1904 | 10,152 | 13 | 7,477 | 167 | 30 | 116,550 | *Nil.* |
| 1905 | 9,920 | 34 | 8,725 | 88 | 220 | 147,155 | *Nil.* |
| 1906 | 7,362 | 8 | 6,786 | 21 | *Nil.* | 164,119 | *Nil.* |
| 1907 | 4,652 | 7 | 5,879 | 31 | 11 | 187,983 | *Nil.* |
| 1908 | 6,787 | 2 | 4,839 | 17 | *Nil.* | 218,851 | *Nil.* |
| 1909 | 11,429 | 24 | 5,187 | 11 | 3 | 216,767 | *Nil.* |
| 1910 | 13,455 | 5 | 6,878 | 34 | ..... | 343,073 | *Nil.* |
| 1911 | 12,569 | 40 | 5,692 | 271 | ..... | 343,850 | 457 |

(a) From *Tabeller vedkommende Norges Bergvaerksdrift und Tabeller vedkommende Norges Handel.* (b) Includes flowers of sulphur. (c) Returns not available. (d) Includes a small quantity of fluorspar. (e) Metric tons. (f) Includes a quantity of sheet aluminum.

# PORTUGAL

The subjoined table reports the mineral production of Portugal:

MINERAL PRODUCTION OF PORTUGAL. (*a*)

(In metric tons.)

| Year. | Antimony Ore. | Arsenic Ore. | Coal (Anthracite.) (*c*) | Copper. | | | |
|---|---|---|---|---|---|---|---|
| | | | | Copper-Iron Pyrite. (*e*) | Other Ores. | Cement. | Matte. |
| 1899..... | 59 | 1,083 | 11,930 | 347,234 | 408 | 2,521 | (*b*) |
| 1900..... | 38 | 1,031 | 24,066 | 402,870 | (*b*) | 2,948 | (*b*) |
| 1901..... | (*b*) | 527 | 16,000 | 443,397 | (*b*) | 2,061 | (*b*) |
| 1902..... | 68 | 736 | 11,000 | 413,714 | 655 | 2,205 | (*b*) |
| 1903..... | 83 | 698 | 8,063 | 376,177 | 527 | 2,448 | (*b*) |
| 1904..... | 31 | 1,370 | 12,805 | 383,581 | 297 | (*b*) | (*b*) |
| 1905..... | 84 | 1,562 | 11,449 | 352,479 | 210 | 2,148 | (*b*) |
| 1906..... | 481 | 1,322 | 6,762 | 350,746 | 196 | 3,634 | (*b*) |
| 1907..... | 383 | 1,538 | 8,824 | 241,771 | 2,478 | 2,942 | 298 |
| 1908..... | 76 | 1,655 | 4,614 | 81,417 | 15,455 | 3,041 | 564 |
| 1909..... | 6 | 1,420 | 6,274 | 12,337 | 1,321 | 3,037 | 309 |
| 1910..... | 25 | 974 | 8,149 | 19,161 | 230 | 3,768 | 230 |
| 1911..... | ..... | 887 | 10,610 | 15,287 | 517 | 3,979 | 283 |
| 1912..... | 100 | 1,006 | 15,626 | 120,148 | 1,309 | 4,028 | ..... |

| Year. | Gold. *Kg.* | Iron Ore. | Lead Ore. (Galena) | Manganese Ore. | Sulphur Ore. | Tin Ore and Metal. | Tungsten Ore. |
|---|---|---|---|---|---|---|---|
| 1899..... | (*d*) 13.0 | 15,078 | 3,468 | 2,949 | (*e*) | 30 | 55 |
| 1900..... | 2.6 | 19,803 | 3,620 | 1,970 | (*e*) | 81 | 49 |
| 1901..... | 2.0 | 21,599 | 445 | 904 | (*e*) | 31 | 90 |
| 1902..... | 2.0 | 19,914 | 1,651 | (*b*) | (*e*) | 24 | 234 |
| 1903..... | 1.3 | 15,200 | 830 | 30 | (*e*) | (*b*) | 228 |
| 1904..... | *Nil.* | 12,488 | 291 | (*b*) | (*e*) | 51 | 290 |
| 1905..... | *Nil.* | 3,200 | 50 | (*b*) | (*e*) | 20 | 358 |
| 1906..... | *Nil.* | (*b*) | 511 | 22 | (*e*) | 22 | 570 |
| 1907..... | 10.5 | (*b*) | 510 | 1,374 | 123,393 | 35 | 226 |
| 1908..... | 57.0 | (*b*) | 481 | (*b*) | 24,522 | 28 | 106 |
| 1909..... | 25.0 | (*b*) | 736 | (*b*) | 272,398 | 18 | 673 |
| 1910..... | 4.1 | 3,360 | 919 | (*b*) | 293,745 | 9 | 948 |
| 1911..... | 3.6 | 19,541 | 1,185 | 6 | 267,486 | 86 | 903 |
| 1912..... | 3.5 | 35,210 | 495 | 6 | 481,295 | 173 | 1,227 |

(*a*) From reports specially furnished *The Mineral Industry* by the Chief of the Department of Mines of the Ministerio das Obras Publicas except for 1904 to 1906 inclusive, which are from official Government reports. The mineral production of the country is identical with exports except in the case of coal. (*b*) Not reported. (*c*) Consumed in the country. (*d*) Metric tons of ore. (*e*) Previous to 1907 the figures for "Sulphur Ore" (largely pyrite) were included under "Copper-Iron Pyrite."

# RHODESIA

The statistics of the mineral production of Rhodesia for the last 12 years are given in the accompanying table.

MINERAL AND METALLURGICAL PRODUCTION OF RHODESIA (*a*).

| Year. | Gold. Ozs. | Value. | Silver. Ozs. | Lead. Tons. (*b*) | Coal. Tons. (*b*) | Year. | Gold. Ozs. | Value. | Silver. Ozs. | Lead. Tons. (*b*) | Coal. Tons. (*b*) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1901... | 172,035 | $2,966,490 | 3,132 | ..... | ..... | 1907.. | 612,052 | 10,589,385 | 147,324 | 756 | 115,073 |
| 1902... | 194,170 | 3,339,286 | 3,445 | ..... | ..... | 1908.. | 606,962 | 12,276,394 | 283,424 | 1,069 | 164,114 |
| 1903... | 231,872 | 4,022,756 | 20,715 | ..... | ..... | 1909.. | 623,388 | 12,985,430 | 262,133 | 965 | 170,893 |
| 1904... | 267,737 | 4,711,016 | 70,146 | 455 | 59,678 | 1910.. | 609,956 | 12,657,791 | 217,633 | 749 | 180,068 |
| 1905... | 407,048 | 7,046,692 | 89,278 | 570 | 97,191 | 1911.. | 628,521 | 12,991,500 | 187,641 | 639 | 212,529 |
| 1906... | 551,894 | 9,647,581 | 110,575 | 652 | 103,803 | 1912.. | 642,807 | 13,174,058 | 176,532 | 587 | 216,140 |

(*a*) From report of Colonel Seely, Under-Secretary of State for the colonies. (*b*) Short tons.

# RUSSIA

The mineral and metallurgical production of Russia, according to official statistics especially reported to THE MINERAL INDUSTRY is given in the subjoined tables.

MINERAL AND METALLURGICAL PRODUCTION OF RUSSIA. (a)

(In metric tons; one metric ton = 61.05 poods.)

| Year. | Asbestos. | Chrome Ore. | Coal. | Copper. | Gold. (b) | Pig-iron. | Lead. | Manganese Ore. |
|---|---|---|---|---|---|---|---|---|
| 1896.. | 1,275 | 6,682 | 9,377,560 | 5,832 | $21,667,269 | 1,620,814 | 261.5 | 191,645 |
| 1897.. | 1,016 | 13,433 | 11,202,750 | 6,940 | 22,194,664 | 1,880,130 | 450.1 | 263,115 |
| 1898.. | 1,665 | 15,466 | 12,307,463 | 7,290 | 22,195,208 | 2,241,293 | 241.2 | 329,276 |
| 1899.. | 2,693 | 19,146 | 13,974,376 | 7,533 | 22,396,315 | 2,708,752 | 321.8 | 659,302 |
| 1900.. | 3,845 | 18,233 | 16,156,055 | 8,258 | 22,369,864 | 2,933,786 | 220.7 | 802,236 |
| 1901.. | 4,398 | 22,169 | 16,526,652 | 8,467 | 22,763,967 | 2,866,779 | 156.0 | 522,395 |
| 1902.. | 4,508 | 19,656 | 16,465,852 | 8,817 | 22,258,343 | 2,598,086 | 225.3 | 536,519 |
| 1903.. | 5,264 | 16,421 | 17,868,515 | 9,232 | 24,147,222 | 2,487,783 | 106.3 | 414,334 |
| 1904.. | 7,502 | 26,575 | 19,608,631 | 9,835 | 24,627,537 | 2,972,115 | 90.3 | 430,090 |
| 1905.. | 5,896 | 27,051 | 18,727,766 | 8,515 | 20,521,587 | 2,628,101 | 700.2 | 508,635 |
| 1906.. | 9,197 | 16,969 | 21,593,158 | 9,296 | 20,020,862 | 2,694,895 | 906.8 | 1,015,686 |
| 1907.. | 9,398 | (g)26,357 | 25,741,321 | 15,930 | 26,518,253 | 3,041,570 | 520.0 | (g)1,003,528 |
| 1908.. | 10,911 | (g)10,950 | (g)25,903,560 | 17,118 | 33,143,810 | 2,818,450 | 522.5 | 362,303 |
| 1909.. | (h)13,129 | ..... | 24,532,349 | 19,656 | 31,889,956 | 2,889,353 | ..... | 574,938 |
| 1910.. | (h)10,936 | ..... | (f)23,105,628 | (f)22,619 | (f) 35,566,045 | (f)3,042,046 | ..... | 668,050 |
| 1911.. | ..... | ..... | (f)16,678,280 | (f)25,097 | (f) 34,550,609 | (f)3,588,449 | ..... | ..... |

| Year. | Petroleum. | Phosphate Rock. | Platinum. (Kg.) | Pyrites. | Quicksilver. | Salt. | Silver. (Kg.) | Sulphur. | Zinc. |
|---|---|---|---|---|---|---|---|---|---|
| 1896... | 6,371,826 | 3,776 | 4,930 | 11,550 | 491 | 1,346,118 | 7,808 | 437 | 6,257 |
| 1897... | 6,945,127 | 5,917 | 5,601 | 19,380 | 616 | 1,561,895 | 4,779 | 574 | 5,874 |
| 1898... | 8,009,828 | 1,867 | 6,016 | 24,570 | 362 | 1,505,602 | 5,143 | 1,018 | 5,664 |
| 1899... | 8,517,608 | 16,863 | 5,962 | 23,250 | 362 | 1,679,726 | 4,419 | 451 | 6,326 |
| 1900... | 9,844,390 | 25,663 | 5,089 | 23,154 | 141 | 1,968,007 | 2,293 | 1,587 | 5,963 |
| 1901... | 10,925,471 | 21,276 | 6,371 | 30,732 | 363 | 1,705,924 | 1,088 | 2,489 | 6,104 |
| 1902... | 10,445,536 | 13,709 | 6,135 | 26,465 | 416 | 1,847,021 | 1,200 | 1,800 | 8,264 |
| 1903... | 9,759,214 | 14,635 | 6,009 | 22,780 | 362 | 1,658,938 | 1,152 | 281 | 9,894 |
| 1904... | 10,058,968 | 20,282 | 5,016 | 31,667 | 332 | 1,908,275 | 726 | 16 | 10,612 |
| 1905... | 7,505,637 | 20,585 | 5,250 | 30,689 | 318 | 1,844,678 | 2,965 | 16 | 7,911 |
| 1906... | 8,167,934 | 18,970 | 5,776 | 20,660 | 210 | 1,730,934 | 430 | 39 | 9,602 |
| 1907... | 9,098,931 | (g)15,457 | 5,903 | 18,316 | (g)132 | 1,873,171 | 7,843 | (d)57 | 10,409 |
| 1908... | 8,732,301 | (g)14,976 | 4,883 | 56,345 | 147 | 1,879,717 | 9,595 | (d)85 | 9,960 |
| 1909... | 8,961,507 | ..... | 5,120 | ..... | ..... | 2,259,690 | 4,109 | ..... | 7,644 |
| 1910... | (e)4,108,108 | ..... | 5,471 | ..... | ..... | 2,047,980 | ..... | ..... | (f)8,631 |
| 1911... | ..... | ..... | (f)5,432 | ..... | ..... | ..... | ..... | ..... | (f)9,652 |

(a) From official sources. (b) The value of gold is taken at $20.67 per ounce. (c) Not reported. (d) Includes sulphide ore. (e) Six months. (f) Statistics of Association of Russian Manufacturers and Traders. (g) St. Petersburg Scientific Committee. (h) The Russian Year Book, Dr. Kennard, London.

# SOUTH AMERICA

The following tables itemize the statistics of the production and the foreign commerce, or both, of mineral and metallurgical products of South American countries so far as available. No statistics later than those given in the tables have been published.

MINERAL AND METAL PRODUCTION OF BOLIVIA. (*a*)

(In metric tons.)

| Year. | Antimony Ore. | Bismuth. | | Cobalt Ore. | Copper. (*c*) | Gold. (*b*) | Silver. (*d*) | Tin Ore. | Tungsten Ore. |
|---|---|---|---|---|---|---|---|---|---|
| | | Metal. | Ore. | | | | | | |
| 1906.... | ..... | 231 | ..... | ..... | 4,347 | $17,403 | ..... | 29,374 | (*e*) 75 |
| 1907.... | 2,279 | 249 | 153.379 | ..... | 3,469 | 3,551 | 3,696 | 27,668 | (*e*)500 |
| 1908.... | 734 | 259 | 160.305 | ..... | 3,027 | 21,617 | 156.5 | 29,938 | 170 |
| 1909.... | ..... | 89 | 236.762 | ..... | 3,097 | ..... | 155.4 | 35,566 | 170 |
| 1910.... | ..... | 97 | 311.060 | ..... | 3,212 | ..... | 143 | 38,548 | 207 |
| 1911.... | 311.7 | ..... | 1,208.689 | ..... | 2,950 | 22,313 | 128.0 | 37,073 | 297 |
| 1912.... | 91.3 | ..... | 45,000 | ..... | 4,681 | 23,038 | 123.9 | 38,379 | 472 |

(*a*) From a British Consular report and Rerista de Aderenas. (*b*) Reduced to U. S. currency. (*c*) Includes ingots, precipitate, matte and concentrate. (*d*) Includes ingots, ore and sulphide. (*e*) U. S. Geol. Surv. (*f*) First half of year.

MINERAL EXPORTS OF BRAZIL. (*a*)

(In metric tons or dollars.) (*d*)

| Year. | Agate. | Carbonado. | Copper Ore. | Diamonds. | Gold. | Manganese Ore. | Mica and Talc. | Monazite. | Platinum. (Grams.) | Precious Stones. (*b*) | Rock Crystal. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1904.. | 54 | $32,063 | 610 | $34,975 | $611,198 | 208,260 | 14.0 | 4,860 | 2,122 | $12,505 | 35 |
| 1905.. | 83 | 113,157 | 658 | 142,459 | 647,581 | 224,377 | 1.0 | 4,437 | 72,000 | 88,463 | 23 |
| 1906.. | 121 | 319,743 | 1,484 | 340,137 | 771,611 | 121,331 | $6,123 | 4,351 | *Nil.* | 141,395 | 37 |
| 1907(*e*) | 53 | 363,200 | (*c*) | 110,457 | 1,976,000 | 236,778 | 8,176 | 4,438 | *Nil.* | 33,335 | 37 |
| 1908(*e*) | 79 | 126,380 | (*c*) | 97,090 | 2,187,950 | 166,122 | 5,540 | 4,965 | *Nil.* | 109,150 | 36 |
| 1909(*e*) | ..... | 177,572 | (*c*) | 58,862 | 2,252,900 | 240,774 | ..... | 6,462 | *Nil.* | 56,338 | ..... |
| 1910(*e*) | 34 | 13,848 | (*c*) | 14,366 | 1,954,674 | 253,953 | ..... | 5,437 | *Nil.* | 745 | ..... |
| 1911(*e*) | 112 | 63,400 | 1 | 103,567 | 2,850,370 | 173,941 | 9 | 371 | *Nil.* | 135,220 | 24 |
| 1912(*e*) | ..... | ..... | ..... | ..... | 2,676,950 | 154,870 | ..... | 3,398 | *Nil.* | 256,693 | ..... |

(*a*) As reported by the *Brazilian Review*. (*b*) Other than carbonado and diamonds. (*c*) Statistics not available. (*d*) The par exchange value of the *Mil Reis* in 1907 was $0.546 U.S. gold. Common exchange value was in 1902, $4.155; in 1903, $4.134; in 1904, $4.146; in 1905, $3.153; in 1906, $3.103, and in 1907, $3.301. (*e*) Reported by U. S. Consul at Rio de Janeiro.

MINERAL PRODUCTION OF CHILE (a).
(In metric tons.)

| Year. | Borax. | Coal. | Cobalt Ore. | Copper. | Gold. Kg. | Guano. | Iodine. | Salt. | Silver, Kg. | Sodium Nitrate. | Sulphur. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1896.. | | (c) | (d) | 23,649 | 1,634 | (f) | (e) | 2,434 | 150,480 | 1,158,088 | 940 |
| 1897.. | | (c) | (d) | 21,128 | 1,538 | (f) | (e) | 5,867 | 140,732 | 1,148,696 | 664 |
| 1898.. | 86,892 | (c) | (d) | 26,331 | 2,037 | (f) | (e) | 6,684 | 131,995 | 1,283,563 | 1,256 |
| 1899.. | (b) | (c) | (d) | 25,719 | 2,060 | (f) | 274 | 9,937 | 129,503 | 1,389,823 | 989 |
| 1900.. | | (c) | (d) | 25,715 | 1,975 | (f) | 302 | 9,879 | 73,071 | 1,460,100 | 2,472 |
| 1901.. | | (c) | (d) | 30,155 | 1,100 | (f) | 269 | 10,099 | 70.237 | 1,273,800 | 2,516 |
| 1902.. | | (c) | (d) | 27,066 | 1,286 | (f) | 242 | 9,532 | 57,418 | 1,400,408 | 2,636 |
| 1903.. | 16,879 | 827,112 | 290 | 29,923 | 994 | 11,134 | 387 | 16,264 | 28,552 | 1,444,920 | 3,360 |
| 1904.. | 16,733 | 751,628 | 125 | 31,025 | 1,135 | 2,669 | 461 | 17,674 | 28,501 | 1,487,598 | 3,294 |
| 1905.. | 19,612 | 793,927 | 28 | 29,126 | 1,055 | 19,380 | 564 | 12,108 | 16,315 | 1,669,806 | 3,470 |
| 1906.. | 28,996 | 932,488 | 0.19 | 25,829 | 1,135 | 4,709 | 331 | 17,116 | 21,216 | 1,822,144 | 4,598 |
| 1907.. | 28,374 | 832,612 | ..... | 28,863 | 1,907 | 7,518 | 4,202 | 18,982 | 28,280 | 1,846,036 | 2,905 |
| 1908.. | 35,039 | 939,836 | ..... | 42,097 | 1,189 | 871 | 330 | 1,626 | 52,435 | 1,970,974 | 2,705 |
| 1909.. | 32,218 | 898,971 | ..... | 42,726 | 1,268 | 10,692 | 474 | 2,046 | 44,283 | 2,101,513 | 4,508 |

(a) From *Estadistica Minera de Chile.* (b) The combined output of the years 1894 to 1902 inclusive. (c) The combined output of Chile up to the end of 1902 is estimated at 20,650,000 tons. (d) The combined output of Chile up to the end of 1902 is estimated at 5941 tons. (e) Not reported. (f) The combined output of Chile up to the end of 1902 is estimated at 163,704 tons, valued at 5,041,569 pesos ($1,840,169).

MINERAL AND METAL PRODUCTION OF PERU. (a)
(In metric tons.)

| Year. | Bismuth. | Borate. | Coal. (b) | Copper. | Gold. Kg. | Lead. | Nickel. Kg. | Petroleum. | Quicksilver. Kg. | Silver. Kg. | Salt. | Sulphur. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1904... | ..... | 2,675 | 59,920 | 9,504 | 601.4 | 2,209 | ..... | 38,683 | ..... | 145,165 | 18,545 | ..... |
| 1905... | 12 | 1,954 | 75,338 | 12,213 | 776.6 | 1,476 | 1,778 | 49,700 | 1,554 | 191,476 | 21,039 | ..... |
| 1906... | ..... | 2,598 | 79,969 | 13,474 | 1,247.0 | 2,568 | ..... | 70,832 | 2,304 | 230,300 | 20,226 | 1,830 |
| 1907... | 48 | 2,451 | 185,565 | 20,681 | 777.6 | 5,525 | ..... | 100,184 | 1,500 | 207,810 | 21,592 | 1,880 |
| 1908... | 9 | 2,870 | 311,122 | 19,854 | 774.0 | 2,633 | ..... | 125,948 | 1,822 | 195,404 | 21,899 | ..... |
| 1909... | 30 | 2,715 | 321,502 | 20,068 | 554.0 | 2,09g | ..... | 188,125 | 350 | 207,656 | 22,715 | ..... |
| 1910... | 24 | 2,351 | 307,320 | 27,376 | 708.0 | 1,866 | ..... | 167,712 | 350 | 252,565 | 17,594 | ..... |
| 1911... | 24 | 1,923 | 324,800 | 27,735 | 741.2 | 2,208 | ..... | 195,276 | 1,923 | 289,383 | 24,867 | ..... |

(a) Reported by the Cuerpo de Ingenieros de Minas del Peru, in its *Boletin.* (b) Includes asphaltum and bituminous schist.

# SPAIN

The following tables record the mineral and metal production of Spain, as reported by official authorities:

MINERAL PRODUCTION OF SPAIN. (*a*)
(In metric tons.)

| Year. | Aluminous Earths. | Antimony Ore. | Arsenic. | Asphaltum. | Asphalt. Rock. | Barytes. | Cement, Hydraulic. | Coal. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Anthracite. | Bituminous. |
| 1898... | 505 | 130 | 111 | 2,354 | 2,383 | 364 | 164,862 | 20,105 | 2,414,127 |
| 1899... | 685 | 50 | 101 | 2,646 | 2,542 | 887 | 165,645 | 34,842 | 2,565,437 |
| 1900... | 420 | 30 | 150 | 2,331 | 4,193 | 833 | 185,811 | 68,427 | 2,514,545 |
| 1901... | 305 | 10 | 120 | 4,182 | 3,956 | 1,067 | 189,909 | 85,266 | 2,566,591 |
| 1902... | 337 | 67 | *Nil.* | 6,034 | 6,301 | 642 | 201,856 | 109,298 | 2,614,010 |
| 1903... | 381 | 42 | 1,088 | 4,675 | 6,277 | 507 | 245,294 | 108,959 | 2,587,652 |
| 1904... | 925 | 245 | 400 | 3,463 | 3,761 | 453 | 286,737 | 163,275 | 2,903,771 |
| 1905... | 221 | 77 | 1,140 | 5,805 | 5,725 | 290 | 296,605 | 159,517 | 2,912,466 |
| 1906... | 386 | 180 | 1,114 | 6,229 | 7,794 | 330 | 299,294 | 113,747 | 3,095,043 |
| 1907... | 1,209 | 205 | 1,500 | 8,643 | 8,219 | 314 | 329,926 | 164,498 | 3,531,337 |
| 1908... | 60 | 124 | 2,004 | 9,231 | 12,373 | 334 | 343,001 | 188,463 | 3,696,653 |
| 1909... | 35 | (*b*) | 506 | 6,582 | 5,284 | 422 | 472,909 | 198,302 | 3,662,573 |
| 1910(*f*) | 400 | 15 | 444 | 8,473 | 7,795 | 476 | 484,161 | 211,958 | 3,600,056 |
| 1911... | 461 | 100 | 331 | 3,495 | 6,500 | 635 | 486,085 | 209,227 | 3,454,394 |

| Year. | Coal (*Continued*). | | Coke. | Copper Ore. | | Copper. | | | Fluorspar. |
|---|---|---|---|---|---|---|---|---|---|
| | Lignitic. | Briquets. | | Argentiferous. | Pyritic. | Fine. | Matte. | Precipitate. | |
| 1898... | 66,422 | 369,418 | 768,151 | 203 | 2,299,444 | 593 | 16,024 | 29,703 | 5 |
| 1899... | 70,901 | 348,838 | 341,443 | 1,103 | 2,443,044 | 4 | 15,755 | 41,927 | 310 |
| 1900... | 91,133 | 341,156 | 381,000 | 2,006 | 2,714,714 | 5 | 18,159 | 29,652 | 4 |
| 1901... | 95,867 | 338,684 | 455,586 | (*b*) | 2,672,365 | 79 | 15,634 | 28,433 | (*b*) |
| 1902... | 84,242 | 331,957 | 404,503 | 878 | 2,617,776 | (*b*) | ..... | 36,045 | 93 |
| 1903... | 104,232 | 339,120 | 433,780 | 3,056 | 2,796,733 | (*b*) | ..... | 27,448 | 4,000 |
| 1904... | 100,773 | 307,630 | 432,726 | (*b*) | 2,624,512 | (*b*) | 8,117 | 29,494 | (*b*) |
| 1905... | 168,994 | 290,830 | 448,073 | (*b*) | 2,621,054 | (*b*) | 8,243 | 17,988 | (*b*) |
| 1906... | 189,048 | 311,328 | 435,808 | (*b*) | 2,888,778 | (*b*) | 9,068 | 19,200 | 70 |
| 1907... | 191,001 | 355,718 | 476,360 | (*b*) | 3,182,645 | (*b*) | 9,886 | 20,887 | 270 |
| 1908... | 223,160 | 296,216 | 477,059 | (*b*) | 2,985,779 | (*b*) | 205 | 19,599 | 253 |
| 1909... | 265,019 | (*b*) | 500,909 | (*b*) | 2,955,254 | (*b*) | 2,077 | 16,641 | 246 |
| 1910(*f*) | 245,518 | 474,891 | 521,078 | (*b*) | 3,231,418 | 85 | 2,684 | 14,056 | 180 |
| 1911... | 252,051 | 478,143 | 516,342 | (*b*) | 3,284,184 | (*g*)76 | 1,910 | 12,353 | 499 |

| Year. | Iron Ore. | | Iron and Steel. | | | Kaolin (China Clay). | Lead (Argentiferous). | |
|---|---|---|---|---|---|---|---|---|
| | Argentiferous. | Non-Argentiferous. | Pig. | Wrought Iron. | Iron and Steel Worked. | | Ore. | Metal. |
| 1898... | 24,490 | 7,197,047 | 113,492 | 65,900 | 50,362 | 5,445 | 244,068 | 88,981 |
| 1899... | 17,139 | 9,397,738 | 113,071 | 40,332 | 112,982 | 2,790 | 184,906 | 70,874 |
| 1900... | 26,348 | 8,675,749 | 91,126 | 54,307 | 144,355 | 3,794 | 182,016 | 74,341 |
| 1901... | 27,726 | 7,906,517 | 135,600 | 47,085 | 121,023 | 2,220 | 207,188 | 73,895 |
| 1902... | 24,361 | 7,904,555 | 330,747 | ..... | 163,564 | 3,412 | 227,645 | 74,370 |
| 1903... | 90,996 | 8,304,153 | 380,284 | ..... | 199,642 | 2,578 | 179,858 | 56,687 |
| 1904... | 122,109 | 7,964,748 | 283,819 | 50,858 | 186,705 | 1,700 | 177,104 | 57,956 |
| 1905... | 152,027 | 9,007,245 | 305,462 | 11,366 | 223,545 | 720 | 160,381 | 56,361 |
| 1906... | 126,445 | 9,448,533 | 315,309 | 6,035 | 274,280 | 610 | 158,425 | 53,856 |
| 1907... | (*b*) | 9,896,178 | 355,240 | 14,767 | 310,125 | 640 | 165,289 | 51,430 |
| 1908... | (*b*) | 9,271,592 | 403,554 | 21,807 | 262,843 | 1,370 | 165,382 | 53,741 |
| 1909... | 3,813 | 8,786,021 | 428,622 | 24,187 | 218,410 | 570 | 161,496 | 43,552 |
| 1910(*f*) | 46,161 | 8,666,795 | 373,322 | 59,133 | 201,798 | 1,496 | 150,592 | 38,548 |
| 1911... | ..... | 8,773,691 | 408,667 | 11,166 | 264,930 | 4,469 | 156,569 | 40,379 |

| Year. | Lead (Non-Argentiferous). | | Manganese Ore. | Mineral Paints (Ocher). | Phosphate Rock. | Pyrites (Iron). | Pyrites (Arsenical). | Quicksilver. | |
|---|---|---|---|---|---|---|---|---|---|
| | Ore. | Metal. | | | | | | Ore. | Metal. |
| 1898 ... | 150,472 | 78,370 | 102,228 | 200 | 4,500 | 70,265 | 230 | 31,361 | 1,661 |
| 1899 ... | 123,753 | 91,730 | 104,974 | 100 | 3,510 | 107,386 | (b) | 32,144 | 1,361 |
| 1900 ... | 131,437 | 98,189 | 112,897 | 58 | 4,170 | 34,638 | 515 | 30,216 | 1,065 |
| 1901 ... | 174,376 | 95,399 | 60,325 | 164 | 4,220 | 33,953 | 1,328 | 23,367 | 734 |
| 1902 ... | 100,403 | 103,190 | 46,069 | (b) | 1,150 | 145,173 | 5,648 | 26,037 | 1,423 |
| 1903 ... | 108,660 | 118,422 | 26,194 | (b) | 1,124 | 155,739 | 7,996 | 30,370 | 968 |
| 1904 ... | 93,230 | 127,906 | 18,732 | (b) | 3,305 | 161,841 | 3,510 | 27,185 | 1,130 |
| 1905 ... | 105,113 | 129,332 | 26,020 | (b) | 1,370 | 179,079 | 4,790 | 26,485 | 853 |
| 1906 ... | 105,095 | 131,614 | 62,822 | 164 | 1,300 | 189,243 | 2,434 | 28,965 | 1,565 |
| 1907 ... | 103,632 | 135,066 | 41,504 | 114 | 3,547 | 225,830 | 3,423 | 28,789 | 1,212 |
| 1908 ... | 126,667 | 134,321 | 16,745 | 400 | 4,483 | 263,451 | 5,533 | 42,210 | 1,068 |
| 1909(f). | 137,050 | 136,441 | 7,827 | 418 | 1,387 | 258,931 | 3,235 | 37,398 | 1,393 |
| 1910 ... | 216,738 | 151,975 | 8,607 | 759 | 2,840 | 294,184 | 1,461 | 22,714 | 1,114 |
| 1911 ... | 165,843 | 149,540 | 5,607 | 622 | 3,520 | 344,879 | 1,056 | 19,940 | 1,494 |

| Year. | Salt. | Silver. | | Soapstone. | Sulphur. | | Tin Ore. Dressed. | Topaz Kg. | Tungsten Ore. | Zinc. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ore. | Metal. Kg. | | Crude Rock. | Refined. | | | | Ore. | Spelter. | Sheets. |
| 1898.. | 479,358 | 967 | 76,295 | 2,613 | 34,943 | 3,100 | 4 | 90 | 37 | 99,836 | 4,300 | 1,731 |
| 1899.. | 598,108 | 764 | 88,409 | 4,814 | 58,922 | 1,100 | 57 | 44 | 151 | 119,710 | 4,100 | 2,084 |
| 1900.. | 450,041 | 742 | 140,457 | 8,109 | 64,364 | 750 | 47 | 95 | 1,958 | 86,158 | 2,855 | 2,756 |
| 1901.. | 345,063 | 391 | 94,977 | 4,880 | 49,856 | 610 | 115 | 310 | 6 | 119,708 | 2,573 | 2,781 |
| 1902.. | 426,434 | 175 | 96,975 | 542 | 15,442 | 450 | 12,762 | Nil. | 11 | 127,618 | 5,569 | (b) |
| 1903.. | 427,394 | 231 | 112,978 | 3,725 | 38,573 | 1,608 | 330 | 90 | Nil. | 154,126 | 5,134 | (b) |
| 1904.. | 543,658 | 303 | 117,418 | 5,165 | 40,389 | 605 | 229 | .... | 60 | 156,329 | 5,887 | 2,913 |
| 1905.. | 493,451 | 540 | 123,607 | 4,364 | 38,153 | 610 | 209 | .... | 375 | 160,561 | 6,184 | 2,936 |
| 1906.. | 541,978 | 470 | 126,424 | 3,609 | 28,965 | 700 | 86 | 171 | 430 | 170,384 | 6,209 | 2,639 |
| 1907.. | 605,895 | 702 | 127,435 | 13,875 | 27,054 | 3,612 | 315 | 266 | 386 | 191,853 | 6,144 | 2,485 |
| 1908.. | 822,677 | 441 | 129,881 | 4,730 | 13,872 | 2,988 | 838 | (b) | 226 | 156,233 | 6,357 | 2,693 |
| 1909(f | 800,703 | 388 | 143,403 | 5,583 | 21,750 | 3,429 | (e)1,555 | (b) | 129 | 163,522 | 9,625 | (b) |
| 1910.. | 678,057 | 217 | 129,157 | 4,665 | 30,113 | 3,834 | 35 | 149 | 153 | 156,113 | 8,557 | 2,722 |
| 1911.. | 654,767 | 858 | 110,082 | 5,647 | 40,662 | 6,580 | 34 | ..... | 96 | 162,140 | 2,904 | 3,429 |

(a) Figures are from *Estadistica Minera de España*, except for 1896 and 1898, which were from the official *Reports of the Junta Superior Facultativa de Minas* Madrid. (b) Not reported. (c) Represents non-argentiferous copper ore. (e) Undressed tin ore. (f) *Revista Minera*. June 24, 1911. (g) Blister copper 18,295 tons; copper sulphate 15,893 tons.

# SWEDEN

The official statistics of mineral production, imports and exports, are summarized in the following tables:

MINERAL PRODUCTION OF SWEDEN. (a)
(In metric tons.)

| Year. | Alum. | Coal. | Copper. | | | Feldspar. | Graphite. | Gold. *Kg.* |
|---|---|---|---|---|---|---|---|---|
| | | | Ore. | Ingot. | Sulphate. | | | |
| 1900..... | 167 | 252,320 | 22,725 | 136 | 1,265 | 15,228 | 85 | 88.5 |
| 1901..... | 121 | 271,509 | 23,660 | 137 | 1,224 | 13,502 | 56 | 62.7 |
| 1902..... | 132 | 304,733 | 30,095 | 178 | 1,257 | 17,960 | 63 | 94.3 |
| 1903..... | 140 | 320,390 | 36,687 | 776 | 1,171 | 19,392 | 25 | 50.6 |
| 1904..... | 125 | 320,984 | 36,834 | 533 | 1,248 | 18,021 | 55 | 60.9 |
| 1905..... | 139 | 322,384 | 39,255 | 1,385 | 1,029 | 19,224 | 40 | 55.0 |
| 1906..... | 167 | 296,980 | 19,655 | 1,209 | 562 | 21,014 | 37 | 20.3 |
| 1907..... | 131 | 305,338 | 21,957 | 1,577 | 782 | 20,244 | 33 | 28.1 |
| 1908..... | 138 | 305,206 | 21,371 | 2,808 | 731 | 17,494 | 66 | 20.3 |
| 1909..... | 132 | 246,808 | 9,562 | 2,375 | 628 | 15,772 | 26 | 14.1 |
| 1910..... | 182 | 302,786 | 3,638 | 3,111 | 20 | 21,591 | 49 | 2. |
| 1911..... | 159 | 311,809 | 1,623 | 3,221 | 320 | 36,235 | 65 | 11. |
| 1912..... | 145 | 360,291 | 3,059 | ..... | ..... | 34,305 | ..... | 30.5 |

| Year. | Iron and Steel. | | | | | Steel. | | |
|---|---|---|---|---|---|---|---|---|
| | Ore. | Pig. | Blooms. | Bars, Rods, Sheets, etc. | Iron Sulphate. | Bessemer. | Basic. | Crucible |
| 1900.... | 2,607,925 | 526,868 | 188,455 | 324,604 | 183 | 91,065 | 207,418 | 1,121 |
| 1901.... | 2,793,566 | 528,375 | 164,850 | 269,507 | 140 | 77,231 | 190,877 | 1,088 |
| 1902.... | 2,896,208 | 538,113 | 186,076 | (b) | 127 | 84,014 | 201,311 | 1,091 |
| 1903.... | 3,677,520 | 506,825 | 192,342 | 325,200 | 62 | 84,229 | 232,878 | 1,105 |
| 1904.... | 4,083,945 | 528,525 | 189,246 | 324,676 | 148 | 78,577 | 252,832 | 1,162 |
| 1905.... | 4,364,833 | 539,437 | 182,640 | 356,898 | 144 | 78,204 | 288,675 | 1,319 |
| 1906.... | 4,501,656 | 604,789 | 178,298 | 381,118 | 170 | 84,633 | 311,435 | 1,457 |
| 1907.... | 4,478,917 | 615,778 | 174,405 | 403,994 | 159 | 77,036 | 341,893 | 1,287 |
| 1908.... | 4,712,494 | 567,821 | 152,256 | 363,408 | 277 | 81,054 | 355,394 | 1,169 |
| 1909.... | 3,885,046 | 444,764 | 120,669 | 292,478 | 182 | 63,351 | 248,757 | 927 |
| 1910.... | 5,549,987 | 603,929 | 151,713 | 408,191 | 236 | 97,503 | 372,451 | 2,215 |
| 1911.... | 6,150,718 | 634,392 | 146,722 | 408,159 | 156 | 93,853 | 372 705 | 4,309 |
| 1912.... | 6,699,226 | 699,816 | ..... | ..... | ..... | 107,254 | 307,637 | ..... |

| Year. | Lead. | Manganese Ore. | Pyrites. | Silver-lead Ore. | Silver. *Kg.* | Sulphur. | Zinc Ore. |
|---|---|---|---|---|---|---|---|
| 1900..... | 1,424 | 2,651 | 179 | 5,300 | 1,927 | 70 | 61,044 |
| 1901..... | 988 | 2,271 | *Nil.* | 11,366 | 1,557 | (b) | 48,630 |
| 1902..... | 843 | 2,850 | *Nil.* | 9,378 | 1,365 | 74 | 48,783 |
| 1903..... | 678 | 2,244 | 7,793 | 9,792 | 1,005 | (b) | 62,927 |
| 1904..... | 589 | 2,297 | 15,957 | 8,187 | 651 | 35 | 57,634 |
| 1905..... | 576 | 1,992 | 20,762 | 8,397 | 606 | 0 | 56,885 |
| 1906..... | 753 | 2,680 | 21,827 | 1,938 | 938 | 0 | 52,552 |
| 1907..... | 813 | 4,334 | 27,113 | 1,987 | 929 | 0 | 50,884 |
| 1908..... | 277 | 4,616 | 29,569 | 2,058 | 630 | 0 | 40,077 |
| 1909..... | 166 | 5,212 | 16,104 | 1,721 | 512 | 0 | 43,760 |
| 1910..... | 355 | 5,752 | 25,445 | 2,700 | 30 | 0 | 49,453 |
| 1911..... | 1,134 | 5,377 | 30,096 | 2,999 | 1,289 | 0 | 51,242 |
| 1912..... | 1,073 | 5,101 | 31,835 | 2,877 | 962 | ..... | 50,096 |

(a) From *Bidrag till Sveriges Officiela Statistik Bergshandteringen.* (b) Not reported.

MINERAL IMPORTS OF SWEDEN. (a)
(In metric tons or dollars; 1 krone = 27 cents).

| Year. | Asbestos. (c) | Asphalt. | Barytes. | Borax. | Boric Acid. | Bromine and Bromides. *Kg.* | Cement. | Chalk, White, Unground. *Hectoliters.* | Coal. |
|---|---|---|---|---|---|---|---|---|---|
| 1899.... | 567 | 6,286 | 292 | 190 | 65 | 4,914 | 1,363 | 16,079 | 3,047,618 |
| 1900.... | 763 | 5,676 | 411 | 194 | 66 | 6,084 | 1,941 | 12,059 | 3,033,885 |
| 1901.... | 178 | 4,524 | 295 | 253 | 68 | 6,602 | 2,868 | 13,569 | 2,793,309 |
| 1902.... | 213 | 5,779 | ..... | 242 | 71 | 7,278 | 9,822 | 11,583 | 2,911,288 |
| 1903.... | 217 | 5,957 | ..... | 240 | 71 | 7,419 | 11,145 | 41,868 | 3,192,990 |
| 1904.... | 356 | 6,243 | ..... | 299 | 77 | 10,128 | 10,526 | 10,115 | 3,367,826 |
| 1905.... | 140 | 4,760 | 264 | 294 | 82 | 18,788 | 10,999 | 13,305 | 3,297,485 |
| 1906.... | 287 | 7,134 | 559 | 321 | 79 | 9,908 | 13,136 | 10,777 | 3,718,884 |
| 1907.... | 672 | 8,213 | 610 | 490 | 85 | 6,784 | 17,801 | (g) 860 | 4,146,785 |
| 1908.... | 505 | 6,368 | 514 | 347 | 71 | 11,499 | 6,158 | (g) 419 | 4,427,507 |
| 1909.... | 383 | 7,922 | 529 | 365 | 76 | 10,280 | 12,944 | (g) 512 | 4,084,055 |
| 1910.... | 671 | 7,406 | 625 | 379 | 92 | 10,913 | 15,438 | (g) 473 | 4,180,250 |
| 1911.... | 1,011 | 6,803 | 607 | 381 | 76 | 16,819 | 24,830 | (g) 605 | 3,964,870 |
| 1912.... | 352 | 7,645 | 644 | 434 | 199 | 9,319 | 17,438 | (g) 422 | 4,293,719 |

| Year. | Copper, also Alloys of Copper. | Emery. | Graphite. | Gypsum | Iron (crude). | Lead. | Litharge. | Phosphorus. *Kg.* | Platinum. *Kg.* |
|---|---|---|---|---|---|---|---|---|---|
| 1899.... | 4,740 | 125 | 162 | 6,457 | 68,909 | 2,125 | 177 | 59,989 | 99 |
| 1900.... | 4,745 | 136 | 213 | 6,794 | 82,957 | 2,067 | 148 | 67,557 | 59 |
| 1901.... | 5,153 | 169 | 180 | 6,589 | 66,131 | 1,991 | 165 | 70,672 | 172 |
| 1902.... | 6,890 | 147 | (b) | 6,754 | 43,828 | 2,509 | 172 | 68,441 | 130 |
| 1903.... | 6,109 | 132 | (b) | 8,795 | 49,411 | 2,644 | 237 | 112,659 | 116 |
| 1904.... | 7,367 | 221 | (b) | 8,868 | 90,102 | 2,849 | 213 | 47,421 | 84 |
| 1905.... | 6,481 | 271 | (b) | 11,270 | 87,843 | 2,823 | 205 | 69,526 | 105 |
| 1906.... | 8,899 | 284 | (b) | 13,496 | 108,193 | 3,457 | 255 | 79,048 | 133 |
| 1907.... | (c) 14,213 | 336 | 375 | 15,037 | 115,186 | 3,384 | 210 | 77,936 | 109 |
| 1908.... | (c) 12,392 | 308 | 540 | 11,644 | 109,841 | 3,964 | 248 | 107,301 | 117 |
| 1909.... | (c) 11,000 | 428 | 443 | 14,212 | 99,519 | 3,222 | 217 | 88,241 | 72 |
| 1910.... | (c) 13,297 | 438 | 398 | 15,816 | 117,180 | 3,453 | 267 | 99,145 | 77 |
| 1911.... | 14,014 | 459 | 398 | 14,505 | 114,859 | 2,901 | 270 | 77,837 | 103 |
| 1912.... | 7,470 | 490 | 513 | 10,467 | 140,145 | 1,204 | 316 | 88,411 | 12 |

| Year. | Potassium. | | | | Quicksilver. *Kg.* | Salt. | | Silver. | |
|---|---|---|---|---|---|---|---|---|---|
| | Chloride. | Cyanide *Kg.* | Hydrate. | Carbonate. | | Crude. | Refined. | Bullion and Mfres. *Kg.* | Specie. |
| 1899.... | 225 | 2,313 | 1,266 | 1,231 | 4,210 | 98,417 | 3,166 | 11,565 | $156,707 |
| 1900.... | 364 | 2,221 | 1,915 | 1,257 | 3,629 | 70,302 | 3,098 | 11,559 | 62,315 |
| 1901.... | 260 | 2,658 | 1,435 | 1,266 | 5,958 | 79,038 | 3,072 | 7,476 | 78,416 |
| 1902.... | 222 | 2,950 | 1,720 | 1,238 | 4,866 | 82,439 | 3,037 | 4,853 | 74,826 |
| 1903.... | 245 | 3,294 | 2,034 | 1,150 | 5,043 | 88,139 | 3,419 | 11,259 | 90,366 |
| 1904.... | 214 | 3,237 | 2,234 | 1,184 | 5,768 | 84,237 | 4,615 | 19,034 | 86,891 |
| 1905.... | 1,296 | 3,437 | 2,251 | 1,133 | 4,609 | 87,677 | 3,889 | 11,067 | 82,620 |
| 1906.... | 1,986 | 4,106 | 2,486 | 1,082 | 5,535 | 88,341 | 3,700 | 15,253 | 93,990 |
| 1907.... | 1,840 | 4,150 | 2,484 | 1,269 | 8,930 | (h) 835,190 | 18,821 | 26,334 | 52,074 |
| 1908.... | 2,190 | 3,563 | 2,835 | 1,209 | 7,299 | (h) 903,633 | 24,394 | 20,149 | 93,669 |
| 1909.... | 1,809 | 3,808 | 2,627 | 1,312 | 6,077 | (h) 766,195 | 24,143 | 17,315 | 154,265 |
| 1910.... | 2,335 | 4,272 | 2,767 | 1,346 | 7,079 | (h) 766,512 | 22,425 | 21,162 | 75,604 |
| 1911.... | 1,288 | 4,993 | 3,737 | 1,268 | 4,164 | (h) 736,935 | 26,026 | 15,175 | 134,407 |
| 1912.... | 228 | 7,545 | (c)3,262 | 1,380 | 5,110 | 1,050 | 22,009 | 21,220 | 164,781 |

| Year | Sodium. | | | | Sulphur. | Sulphuric Acid. | Tin. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Carbonate. | Hydrate. | Nitrate. (*d*) | Sulphate (*e*). | | | Salts-*Kg.* | Block. | Zinc. |
| 1900.... | 12,680 | 1,038 | 14,245 | 15,590 | 20,152 | 2,472 | 3,243 | 630 | 2,912 |
| 1901.... | 13,669 | 800 | 17,614 | 15,494 | 20,715 | 1,950 | 2,334 | 541 | 2,900 |
| 1902.... | ..... | 1,623 | 15,553 | 18,924 | 23,002 | 1,887 | 1,652 | 644 | 3,255 |
| 1903.... | ..... | 1,426 | 20,616 | 16,120 | 24,577 | 2,620 | 1,467 | 655 | 3,312 |
| 1904.... | 11,898 | 2,112 | 19,776 | 17,596 | 18,248 | 2,001 | 1,460 | 719 | 3,705 |
| 1905.... | 13,592 | 1,489 | 23,183 | 17,115 | 18,631 | 3,424 | 1,722 | 597 | 3,780 |
| 1906.... | 14,974 | 1,478 | 27,174 | 19,948 | 22,745 | 2,535 | 1,102 | 819 | 4,484 |
| 1907.... | 14,970 | 1,628 | 26,181 | 21,486 | 25,456 | 2,628 | 6,117 | 891 | 5,407 |
| 1908.... | 14,149 | 1,256 | 27,631 | 18,717 | 30,806 | 3,073 | 2,817 | 808 | 4,626 |
| 1909.... | 13,490 | 1,119 | 28,849 | 20,226 | 26,836 | 1,955 | 1,357 | 794 | 5,294 |
| 1910.... | 15,594 | 1,260 | 32,315 | 22,429 | 38,530 | 2,707 | 1,161 | 764 | 5,843 |
| 1911.... | 15,777 | 2,501 | 31,324 | 27,482 | 34,622 | 861 | 915 | 866 | 5,951 |
| 1912.... | 18,255 | ..... | 35,107 | 26,540 | 38,471 | 593 | 73,045 | 1,032 | 4,617 |

## MINERAL EXPORTS OF SWEDEN. (*a*)

(In metric tons or dollars; 1krone = 27 cents.)

| Year. | Alum. | Ammonium Sulphate | Antimony, Crude-*Kg.* | Asbestos. *Kg.* | Cement. | Coal. (Anthracite.) | Copper. | | Graphite. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Ore. | Copper and Alloys. | |
| 1898 ... | 32 | 36 | 4,700 | 1,055 | 28,676 | 496 | 1,102 | 1,346 | 9 |
| 1899 ... | 26 | 2 | 2,600 | 2,812 | 31,101 | 762 | 315 | 1,230 | 17 |
| 1900 ... | 24 | 2 | 4,600 | 2,436 | 42,564 | 1,108 | 448 | 2,012 | 18 |
| 1901 ... | 56 | 156 | 1,800 | 2,179 | 17,794 | 716 | 602 | 1,243 | 19 |
| 1902 ... | 20 | 174 | 4,090 | 1,864 | 19,499 | 866 | 845 | 1,516 | 5 |
| 1903 ... | 22 | *Nil.* | 3,473 | 15,357 | 21,319 | 509 | 1,555 | 1,858 | 9 |
| 1904 ... | 9 | 219 | 3,810 | 16,339 | 27,509 | 605 | 749 | 1,396 | (*b*) |
| 1905 ... | 12 | 445 | 3,147 | 2,386 | 38,504 | 425 | 2,137 | 2,654 | (*b*) |
| 1906 ... | 11 | 30 | 4,584 | 1,510 | 45,960 | 1,352 | 1,841 | 2,662 | (*b*) |
| 1907 ... | 7 | *Nil.* | 4,485 | 2,167 | 18,053 | 2,925 | 882 | 2,762 | 8 |
| 1908 ... | 9 | 202 | 4,188 | 1,612 | 34,164 | 1,293 | 1,114 | 3,299 | 18 |
| 1909 ... | 5 | 331 | 6,536 | 1,093 | 33,197 | 771 | 723 | 3,264 | 7 |
| 1910 ... | 11 | 704 | 4,555 | 1,242 | 73,351 | 776 | 878 | 2,580 | 7 |
| 1911 ... | 2 | 253 | 7,320 | 760 | 108,653 | 1,045 | 1,114 | 2,500 | 12 |
| 1912 ... | 15 | 42 | 9,151 | 20 | 127,142 | 684 | 1,577 | 4,273 | 9 |

| Year. | Gypsum and Mfres. | Iron and Steel. | | Lead and Mfres. | Peat. | Phosphorus. *Kg.* | Potassium Chloride. |
|---|---|---|---|---|---|---|---|
| | | Ore. | Unwrought. | | | | |
| 1898..... | 27 | 1,439,860 | 301,192 | 570 | 1,616 | 4,085 | 506 |
| 1899..... | 8 | 1,628,011 | 320,742 | 818 | 1,979 | 1,890 | 335 |
| 1900..... | 10 | 1,619,902 | 304,175 | 1,209 | 3,843 | 879 | 931 |
| 1901..... | 55 | 1,761,257 | 268,143 | 1,028 | 3,064 | 1,254 | 708 |
| 1902..... | 117 | 1,729,000 | (*f*) 73,403 | 546 | 3,620 | 1,290 | 1,114 |
| 1903..... | 119 | 2,828,000 | (*f*) 70,788 | 333 | 3,217 | 300 | 790 |
| 1904..... | 162 | 3,065,522 | (*f*) 88,124 | 275 | 4,212 | 1,994 | 1,266 |
| 1905..... | 156 | 3,316,626 | (*f*)120,987 | 512 | 5,157 | 34,388 | 1,499 |
| 1906..... | 6 | 3,661,218 | (*f*)112,719 | 531 | 6,531 | 700 | (*b*) |
| 1907..... | 16 | 3,521,717 | 201,643 | 519 | 6,524 | (*b*) | (*b*) |
| 1908..... | 37 | 3,654,268 | 159,095 | 496 | 5,559 | 400 | 1,363 |
| 1909..... | 21 | 3,204,522 | 161,757 | 319 | 9,999 | 1,305 | 1,400 |
| 1910..... | 41 | 4,434,805 | 213,861 | 557 | 9,754 | 265 | 1,383 |
| 1911..... | 13 | 5,086,898 | 226,044 | 1,181 | 10,371 | 595 | 1,564 |
| 1912..... | 2 | 5,520,653 | 213,619 | 1,003 | ..... | 600 | 1,653 |

| Year. | Salt. Refined *Kg.* | Silver. Bullion. *Kg.* | Soda. (Carbonate.) | Sulphur. | Tin. | | Zinc. | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Block and Scrap. | Mfres-*Kg.* | Ore. | Crude and Mfrs. |
| 1898.... | 216 | 130 | 509 | 11 | 20.8 | 1,263 | 49,597 | 185 |
| 1899.... | 110 | 367 | 227 | 68 | 8.8 | 1,033 | 45,635 | 157 |
| 1900.... | 407 | 296 | 238 | 20 | 21.5 | 1,521 | 40,879 | 157 |
| 1901.... | 1,556 | 179 | 237 | 12 | 20.4 | 8,110 | 41,248 | 101 |
| 1902.... | 1,945 | 110 | 621 | 147 | 25.5 | 1,603 | 43,813 | 63 |
| 1903.... | *Nil.* | 484 | 10 | 217 | 43.3 | 3,893 | 45,389 | 351 |
| 1904.... | 1,883 | 115 | 45 | 4 | 45.6 | 3,479 | 44,259 | 332 |
| 1905.... | *Nil.* | 10 | 403 | 4 | 33.9 | 654 | 51,765 | 295 |
| 1906.... | 8,652 | 77 | 463 | 12 | 51.0 | 353 | 45,380 | 410 |
| 1907.... | 4,452 | 160 | 39 | 1 | 67.9 | 2,518 | 41,236 | 529 |
| 1908.... | 14,300 | 136 | 114 | 7 | 53.9 | 274 | 38,543 | 908 |
| 1909.... | 6,422 | 437 | 27 | 5 | 42.5 | 276 | 38,865 | 1,200 |
| 1910.... | 1,326 | 814 | 31 | 6 | 51.1 | 356 | 40,405 | 1,278 |
| 1911.... | 3,450 | 1,090 | 40 | 7 | 66.0 | 152 | 41,854 | 2,158 |
| 1912.... | 1,668 | 2,021 | 3 | 75 | 110.0 | 698 | 41,985 | 3,136 |

(*a*) From *Bidrag till Sveriges Officiella Statistik* and *Sveriges Utförsel och Införsel.* (*b*) Not reported. (*c*) Includes crude and manufactures. (*d*) Includes a small quantity of potassium nitrate. (*e*) Includes sodium bisulphate. (*f*) Includes only crude or ballast iron. (*g*) Metric tons. (*h*) Hectoliters. (*i*) Includes sodium hydroxide.

# UNITED KINGDOM

The statistics of the mineral production, imports and exports, according to official reports, are given in the subjoined tables.

MINERAL AND METALLURGICAL PRODUCTION OF THE UNITED KINGDOM. (*a*)
(In metric tons.)

| Year. | Alum Shale. | Arsenious Acid. | Arsenical Pyrites. | Barium Minerals. | Bauxite. | Chalk. | Clay. (*e*) | Coal. |
|---|---|---|---|---|---|---|---|---|
| 1900.... | 1,329 | 4,146 | 9,727 | 29,937 | 5,871 | 4,444,765 | 14,279,181 | 228,772,886 |
| 1901.... | 4,019 | 3,416 | 2,620 | 26,844 | 10,357 | 4,399,043 | 14,393,196 | 222,614,981 |
| 1902.... | 5,755 | 2,165 | 842 | 23,986 | 9,192 | 4,466,004 | 15,549,002 | 230,728,562 |
| 1903.... | 3,337 | 916 | 58 | 24,659 | 6,226 | 4,541,494 | 16,460,526 | 234,019,821 |
| 1904.... | 6,636 | 992 | 44 | 26,748 | 8,839 | 4,509,768 | 16,210,734 | 236,130,373 |
| 1905.... | 7,245 | 1,552 | 651 | 29,528 | 7,417 | 4,608,153 | 15,376,910 | 239,906,999 |
| 1906.... | 9,605 | 1,625 | 650 | 36,319 | 6,760 | 4,825,299 | 12,459,213 | 255,067,622 |
| 1907.... | 10,063 | 1,523 | 1,800 | 42,648 | 7,658 | 4,855,857 | 15,065,141 | 272,097,858 |
| 1908.... | 5,459 | 2,007 | 3,270 | 39,572 | 11,904 | 4,329,983 | 14,638,710 | 265,726,332 |
| 1909.... | 9,266 | 2,926 | 182 | 42,436 | 9,652 | 4,508,136 | 14,293,598 | 268,007,890 |
| 1910.... | 6,781 | 2,187 | 958 | 45,384 | 4,208 | 4,705,766 | (*h*)14,316,469 | 268,677,182 |
| 1911.... | 10,685 | 2,178 | 1,189 | 44,826 | 6,103 | ..... | 14,057,090 | 276,255,764 |
| 1912.... | ..... | 2,228 | 1,806 | 43,453 | 5,882 | 4,962,408 | ..... | 264,749,661 |

| Year. | Copper. | | Fluorspar. | Gold. | | Gravel and Sand. | Gypsum. | Bog Ore (Ireland) (*c*) |
|---|---|---|---|---|---|---|---|---|
| | Ore and Precipitate. | Fine. | | Ore. | Bullion. *Kg.* | | | |
| 1900..... | 9,643 | 777 | 1,472 | 21,135 | 437.6 | 1,867,211 | 211,436 | 4,221 |
| 1901..... | 6,903 | 541 | 4,232 | 16,641 | 194.5 | 1,990,926 | 204,045 | 2,649 |
| 1902..... | 6,210 | 490 | 6,388 | 30,432 | 130.0 | 2,100,829 | 228,264 | 4,983 |
| 1903..... | 6,977 | 545 | 12,102 | 29,057 | 171.0 | 2,281,689 | 223,426 | 4,156 |
| 1904..... | 5,552 | 501 | 18,450 | 23,574 | 610.7 | 2,275,426 | 237,749 | 4,616 |
| 1905..... | 7,267 | 727 | 40,079 | 16,237 | 169.0 | 2,277,486 | 259,596 | 3,256 |
| 1906..... | 7,882 | (*b*) | 42,521 | 17,662 | (*b*) | 2,404,857 | 228,627 | 5,512 |
| 1907..... | 6,867 | 677 | 50,257 | 13,186 | 59.4 | 2,438,798 | 239,285 | 6,391 |
| 1908..... | 5,528 | 588 | 35,257 | 7,237 | 28.5 | 2,228,245 | 231,980 | 4,364 |
| 1909..... | 3,777 | 442 | 43,165 | 5,627 | 37.6 | 2,199,583 | 242,832 | 2,719 |
| 1910..... | 4,245 | 456 | 62,607 | 6,252 | 75.5 | 2,235,160 | 259,661 | 2,603 |
| 1911..... | 3,314 | 398 | 56,117 | 2,796 | 13.2 | 2,311,694 | 281,125 | 2,743 |
| 1912..... | 1,942 | ..... | ..... | 173 | (*b*) | ..... | 247,724 | (*b*) |

| Year. | Iron. | | Lead. | | Manganese Ore. | Mineral Paints. | Oil Shale. | Phosphate of Lime. |
|---|---|---|---|---|---|---|---|---|
| | Ore. | Pig. | Ore. | Pig. | | | | |
| 1900.... | 14,257,344 | 4,743,172 | 32,487 | 24,762 | 1,384 | 15,448 | 2,318,736 | 630 |
| 1901.... | 12,475,700 | 4,158,745 | 33,084 | 20,361 | 1,673 | 14,780 | 2,392,812 | 71 |
| 1902.... | 13,641,459 | 4,470,420 | 25,000 | 17,988 | 1,299 | 17,235 | 2,141,355 | 87 |
| 1903.... | 13,935,748 | 4,573,202 | 26,993 | 20,278 | 831 | 14,377 | 2,041,851 | 71 |
| 1904.... | 13,994,670 | 4,596,803 | 26,796 | 20,155 | 8,896 | 16,307 | 2,370,391 | 59 |
| 1905.... | 14,824,183 | (*f*)9,746,221 | 28,091 | 20,977 | 14,582 | 16,468 | 2,536,784 | *Nil.* |
| 1906.... | 15,748,412 | (*f*)9,999,211 | 30,710 | 22,693 | 23,126 | 14,437 | 2,586,851 | *Nil.* |
| 1907.... | 15,983,310 | (*f*)9,850,953 | 33,053 | 24,853 | 16,356 | 14,927 | 2,732,968 | 33 |
| 1908.... | 15,272,273 | 4,925,250 | 29,718 | 21,336 | 6,409 | 15,643 | 2,938,456 | 9 |
| 1909.... | 15,220,408 | (*f*)9,818,916 | 30,221 | 22,823 | 2,812 | 16,575 | 3,014,678 | 4 |
| 1910.... | 15,470,392 | 5,055,595 | 28,992 | 21,867 | 5,554 | 16,782 | 3,180,520 | (*b*) |
| 1911.... | 15,768,511 | 5,101,089 | 24,186 | 18,279 | 5,067 | 14,819 | 3,166,838 | (*b*) |
| 1912.... | 8,552,343 | ..... | 25,729 | ..... | 4,237 | ..... | 3,235,942 | ..... |

| Year. | Pyrites. | Salt. | Silica (chert and flint). | Silver. *Kg.* | Stone. | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Igneous Rock. | Limestone. (*d*) | Sandstone. | Slate. |
| 1900..... | 12,484 | 1,873,601 | 78,971 | 5,964 | 4,709,997 | 12,099,940 | 5,101,868 | 595,428 |
| 1901..... | 10,405 | 1,812,180 | 132,700 | 5,452 | 5,131,787 | 11,363,202 | 5,199,234 | 496,756 |
| 1902..... | 9,315 | 1,893,881 | 100,938 | 4,560 | 5,554,696 | 12,368,196 | 5,571,121 | 525,665 |
| 1903..... | 9,794 | 1,917,274 | 74,355 | 5,440 | 5,512,605 | 12,419,120 | 5,496,312 | 540,143 |
| 1904..... | 10,452 | 1,921,899 | 66,300 | 4,967 | 6,084,642 | 12,235,825 | 5,391,265 | 572,181 |
| 1905..... | 12,381 | 1,920,149 | 71,808 | 5,212 | 6,052,210 | 12,701,808 | 5,729,799 | 523,892 |
| 1906..... | 11,318 | 1,996,593 | 69,300 | (*b*) | 6,264,402 | 12,962,725 | 5,345,328 | 500,546 |
| 1907..... | 10,358 | 2,016,409 | 54,523 | 4,780 | 5,765,262 | 12,709,288 | 5,092,246 | 450,651 |
| 1908..... | 9,600 | 1,873,555 | 64,813 | 4,207 | 6,211,860 | 11,977,007 | 5,105,481 | 420,979 |
| 1909..... | 8,964 | 1,851,999 | 53,063 | 4,421 | 6,384,144 | 12,000,790 | 4,673,839 | 408,639 |
| 1910..... | 10,393 | 2,083,543 | 75,089 | 4,251 | 6,714,774 | 12,713,565 | 4,456,679 | 423,006 |
| 1911..... | 10,276 | 2,116,115 | 72,726 | 3,684 | 6,629,417 | 12,378,725 | 4,109,828 | 431,948 |
| 1912..... | 10,691 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

| Year. | Strontium Sulphate. | Tin. | | Tungsten Ore. | Uranium Ore. | Zinc. | |
|---|---|---|---|---|---|---|---|
| | | Ore Dressed. | Block. | | | Ore. | Spelter. |
| 1900..... | 9,270 | 6,911 | 4,337 | 9 | 42 | 25,070 | 9,214 |
| 1901..... | 16,923 | 7,407 | 4,634 | 21 | 80 | 23,967 | 8,555 |
| 1902..... | 32,799 | 7,681 | 4,462 | 9 | 53 | 25,462 | 9,275 |
| 1903..... | 23,209 | 7,500 | 4,351 | 276 | 6 | 25,287 | 9,430 |
| 1904..... | 18,460 | 6,849 | 4,198 | 164 | *Nil.* | 28,097 | 10,427 |
| 1905..... | 14,523 | 7,316 | 4,540 | 174 | 105 | 24,025 | 9,023 |
| 1906..... | 14,338 | 6,376 | (*b*) | 267 | 11 | 23,189 | (*b*) |
| 1907..... | 10,917 | 7,192 | 4,478 | 327 | 72 | 20,402 | 7,222 |
| 1908..... | 16,733 | 8,137 | 5,133 | 237 | 72 | 15,469 | 5,926 |
| 1909..... | 14,267 | 8,422 | 5,282 | 382 | 6 | 10,061 | 5,828 |
| 1910..... | 4,838 | 7,693 | 4,874 | 275 | 76 | 11,418 | 4,235 |
| 1911..... | 5,963 | 7,870 | 4,950 | 270 | 68 | 17,935 | 6,196 |
| 1912..... | ..... | 6,926 | ..... | 192 | 43 | 17,988 | ..... |

(*a*) From *Mineral Statistics of the United Kingdom.* (*b*) Not reported. (*c*) Bog ore, which is mined in Ireland, is an ore of iron, used principally for purifying gas. (*d*) Does not include chalk. (*e*) Includes China clay, potters' clay, and fuller's earth. (*f*) Includes production from imported ore. (*g*) Estimated. (*h*) Includes shale. (*i*) Partial figures available only.

MINERAL IMPORTS OF THE UNITED KINGDOM. (*a*)

(In metric tons or dollars; £1 = $5.)

| Year. | Alkali. | Asphaltum. | Borax. | Coal, Coke and Pat. Fuel. | Copper. | | | Iron and Steel. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Ore. | Regulus and Precipitate. | Wrought, Unwrought and Old. | Iron Ore. | Pig Iron. | Scrap. |
| 1901... | (*c*)13,429 | 74,694 | 15,710 | 7,685 | 102,503 | 93,338 | 68,809 | 5,637,670 | 198,536 | 44,721 |
| 1902... | (*c*)26,292 | 65,896 | 13,390 | 3,331 | 90,007 | 74,684 | 92,349 | 6,542,793 | 226,708 | 39,584 |
| 1903... | (*c*)14,321 | (*b*) | 11,959 | 3,535 | 85,644 | 77,884 | 64,591 | 6,417,188 | 132,364 | 17,051 |
| 1904... | (*c*)14,325 | (*b*) | 16,012 | 2,812 | 80,771 | 67,739 | 90,717 | 6,198,368 | 132,494 | 19,326 |
| 1905... | (*c*)16,593 | (*b*) | 11,552 | 49,277 | 94,198 | 70,235 | 71,294 | 7,172,171 | 128,183 | 23,589 |
| 1906... | (*c*)14,070 | (*b*) | 16,955 | 49,269 | 97,789 | 76,073 | 75,487 | 7,634,839 | 90,674 | 36,559 |
| 1907... | (*c*)15,579 | (*b*) | 17,551 | 19,136 | 105,409 | 73,101 | 89,312 | 7,764,589 | 104,950 | 27,404 |
| 1908(*i*) | (*c*)13,732 | (*b*) | (*n*)19,424 | 3,904 | 111,897 | 71,120 | 124,226 | 6,154,733 | 69,930 | 24,653 |
| 1909... | (*c*)10,857 | (*b*) | (*n*)16,349 | 6,419 | (*l*)90,579 | (*l*)66,337 | (*l*)133,758 | (*l*)6,429,996 | (*l*)111,300 | (*l*)33,475 |
| 1910... | (*c*) 8,996 | (*o*)14,415 | 16,277 | 36,615 | 99,755 | 70,081 | 89,279 | 7,133,483 | 173,568 | 70,176 |
| 1911... | (*c*) 9,463 | (*o*)20,866 | 20,621 | 30,672 | 87,986 | 65,914 | 101,059 | 6,448,462 | 178,167 | 51,002 |
| 1912... | 8,812 | (*b*) | 21,091 | 194,866 | 99,802 | 52,393 | 96,499 | 6,708,443 | 223,586 | 64,195 |

| Year. | Iron and Steel. (*Continued*). | | | | | | | | Lead. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Puddled and Wrought | Sheets and Plates. | Rails. | Strips and Wire Rods. | Nails, Screws, Rivets, Bolts. | Steel Ingots, Blooms, Billets, etc. | Steel Bars, Shapes, Beams, Pillars. | Mnfrs. Unenumerated. (*h*) | Ore. | Pig and Sheet. |
| 1900.. | 189,891 | (*f*) | 38,636 | (*f*) | (*f*) | 182,210 | 94,667 | $17,861,660 | 21,566 | 198,416 |
| 1901.. | 102,811 | (*f*) | 55,809 | (*f*) | (*f*) | 185,810 | 124,648 | 18,252,435 | 29,944 | 221,549 |
| 1902.. | 178,425 | (*f*) | 48,942 | (*f*) | 45,095 | 285,494 | 129,743 | 14,424,835 | 25,838 | 235,522 |
| 1903.. | 196,084 | 73,079 | 74,939 | 35,574 | 51,888 | 278,441 | 343,259 | 9,007,990 | 18,923 | 232,939 |
| 1904.. | 109,289 | 69,552 | 40,438 | 38,214 | 50,649 | 531,069 | 219,510 | 8,630,380 | 8,748 | 250,452 |
| 1905.. | 110,576 | 69,831 | 34,439 | 60,318 | 55,331 | 613,612 | 148,995 | 8,783,895 | (*i*) 27,649 | 233,214 |
| 1906.. | 111,062 | 83,747 | 11,900 | 61,288 | 57,071 | 493,805 | 149,363 | 7,824,405 | (*i*) 30,795 | 211,577 |
| 1907.. | 83,145 | 57,280 | 19,33 | 56,110 | 51,863 | 332,442 | 90,327 | 3,731,275 | (*i*) 13,609 | 207,970 |
| 1908(*i*) | 85,270 | 56,652 | 31,393 | 109,313 | 54,251 | 437,238 | 231,859 | 3,034,895 | 23,861 | 241,320 |
| 1909.. | (*l*) 95,553 | (*l*) 68,067 | (*l*) 22,430 | (*l*) 132,543 | (*l*) 59,197 | (*l*) 392,008 | (*l*) 264,909 | 2,819,365 | (*b*) | (*l*) 210,982 |
| 1910.. | (*l*) 98,859 | 88,245 | 16,074 | 163,681 | 58,977 | 361,401 | 349,662 | 3,239,715 | (*b*) | 222,450 |
| 1911.. | 119,583 | 115,349 | 36,588 | 173,764 | 62,314 | 512,841 | 500,643 | (*p*) 3,654,825 | (*b*) | 217,134 |
| 1912.. | 167,774 | 103,224 | 24,640 | 205,749 | 73,745 | 607,470 | 509,002 | 4,270,000 | (*b*) | 208,671 |

| Year. | Manganese Ore. | Mica, Sheet. | Mica and Talc. | Paraffin. | Petroleum. *Liters.* | Phosphate Rock. | Platinum, Wrought and Unwrought. *Kg.* | Potassium Nitrate. | Pyrites of Iron and Copper. |
|---|---|---|---|---|---|---|---|---|---|
| 1900..... | 270,098 | 469 | 7,952 | 50,033 | 965,167,850 | 361,309 | 5,027 | 12,798 | 752,605 |
| 1901..... | 195,736 | (*b*) | 7,117 | 42,643 | 960,650,967 | 360,568 | 4,917 | 12,115 | 664,041 |
| 1902..... | 237,066 | 1,078 | 6,127 | 52,023 | 1,078,095,152 | 370,697 | 3,027 | 11,526 | 620,948 |
| 1903..... | 235,574 | (*b*) | (*b*) | 49,163 | 1,299,570,625 | 398,997 | (*b*) | 9,425 | 747,714 |
| 1904..... | 208,458 | (*b*) | (*b*) | 42,882 | 1,373,488,176 | 425,978 | (*b*) | 12,277 | 754,722 |
| 1905..... | 289,827 | (*b*) | (*b*) | 41,247 | 1,364,301,583 | 427,762 | (*b*) | 8,260 | 709,926 |
| 1906..... | 314,016 | (*b*) | (*b*) | 44,673 | 1,130,667,737 | 450,058 | (*b*) | 10,125 | 771,473 |
| 1907..... | 513,750 | (*b*) | (*b*) | 46,542 | 1,382,595,355 | 512,601 | (*b*) | 10,719 | 781,486 |
| 1908 (*i*).... | 349,694 | (*b*) | (*b*) | (*n*) 46,504 | (*n*) 1,300,726,576 | 537,628 | (*b*) | (*n*) 11,913 | 771,091 |
| 1909..... | 335,813 | (*b*) | (*b*) | (*n*) 53,289 | (*n*) 1,355,562,599 | 459,058 | (*b*) | (*n*) 10,704 | (*l*) 803,725 |
| 1910..... | 489,948 | (*b*) | (*b*) | (*n*) 54,073 | (*n*) 1,308,396,240 | 462,905 | (*b*) | 11,558 | 825,284 |
| 1911..... | 364,676 | (*b*) | (*b*) | 51,456 | 1,661,100,144 | 501,332 | (*b*) | 11,376 | 863,583 |
| 1912..... | 393,798 | (*b*) | (*b*) | 74,836 | 1,879,486,588 | 528,620 | (*b*) | 11,034 | 921,717 |

| Year. | Quicksilver. | Silver Ore. (*d*) | Sodium Nitrate. | Sulphur. | Tin. | | Zinc. | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Ore. | Block, Ingot, Bars or Slabs. | Ore. | Spelter. | Mnfres. |
| 1900..... | 1,113 | 5,154,430 | 143,461 | 22,993 | 7,449 | 33,648 | 42,755 | 61,504 | 21,751 |
| 1901..... | 1,202 | 5,309,920 | 108,822 | 22,440 | 10,690 | 35,397 | 38,660 | 68,633 | 21,343 |
| 1902..... | 1,129 | 5,383,515 | 116,791 | 23,863 | 12,255 | 37,713 | 45,312 | 89,688 | 21,717 |
| 1903..... | 1,187 | 6,596,045 | 118,582 | 21,313 | 12,473 | 36,076 | 41,009 | 86,539 | 23,118 |
| 1904..... | 1,130 | 8,271,480 | 122,454 | 17,629 | 15,734 | 39,932 | 54,438 | 90,088 | 22,788 |
| 1905..... | 1,158 | 10,426,570 | 106,107 | 18,163 | (*b*) | 40,391 | 23,909 | 92,261 | 20,013 |
| 1906..... | 1,320 | 10,532,020 | 110,222 | 22,704 | 21,003 | 44,306 | (*i*) 22,824 | 95,203 | 19,664 |
| 1907..... | 1,341 | 11,224,650 | 115,716 | 15,730 | 21,205 | 44,505 | (*i*) 66,076 | 90,756 | 20,163 |
| 1908(*i*)..... | 1,483 | 10,743,400 | (*n*) 148,056 | (*n*) 19,580 | 25,414 | 48,496 | 61,661 | 91,548 | 38,717 |
| 1909..... | (*m*) 1,469 | 10,409,800 | (*n*) 91,650 | 21,211 | (*m*) 24,471 | (*l*) 42,393 | (*b*) | 104,217 | 19,280 |
| 1910..... | 1,517 | 9,311,665 | 128,528 | 20,496 | 26,490 | 47,028 | (*b*) | 123,061 | 18,460 |
| 1911..... | 1,584 | 8,420,954 | 130,549 | 21,269 | 29,300 | 46,643 | (*b*) | 117,077 | 19,417 |
| 1899..... | 1,607 | 7,523,692 | 125,664 | 22,109 | 29,112 | 43,850 | (*b*) | 139,461 | 20,673 |

(*a*) From *Accounts Relating to Trade and Navigation of the United Kingdom.* (*b*) Not reported. (*c*) Classified as soda compounds since 1901. (*d*) Includes the value of silver in argentiferous ore and metal. (*e*) Includes puddled iron. (*f*) Not separately enumerated. (*g*) Returns not available. (*h*) Prior to 1900, many manufactures were not reported separately. (*i*) From *Mines and Quarries.* (*l*) From *Iron and Coal Trades Review.* (*m*) *Min. Journ.* (*n*) *Oil, Paint and Drug Reporter.* (*o*) From Trinidad. (*p*) There are besides, not here given, pipes, castings and forgings, amounting to 51,000 tons.

MINERAL EXPORTS OF THE UNITED KINGDOM—DOMESTIC PRODUCTS. (a)
(In metric tons or dollars; £1 = $5.)

| Year. | Bleaching Materials. | Cement. | Coal. | Coke. | Patent Fuel. | Supplied to Steamers. | Coal Products (c). |
|---|---|---|---|---|---|---|---|
| 1900 | 57,478 | 365,742 | 46,845,739 | 1,001,131 | (b) | 11,940,353 | 9,058,220 |
| 1901 | 46,912 | 318,216 | 42,547,114 | 820,594 | 1,098,459 | 13,804,222 | 5,756,265 |
| 1902 | 40,939 | 308,104 | 43,849,591 | 669,664 | 1,067,060 | 15,390,485 | 5,991,025 |
| 1903 | 49,415 | 406,388 | 45,669,258 | 728,957 | 970,449 | 17,068,646 | 7,290,825 |
| 1904 | 35,289 | 390,736 | 46,995,636 | 779,060 | 1,257,589 | 17,465,954 | 6,879,400 |
| 1905 | 42,526 | 463,863 | 48,236,334 | 786,498 | 1,126,190 | 17,674,484 | 6,742,455 |
| 1906 | 45,510 | 668,461 | 56,489,367 | 828,266 | 1,399,244 | 18,887,656 | 7,226,790 |
| 1907 | 48,856 | 777,741 | 64,621,743 | 997,170 | 1,504,661 | 18,917,660 | 7,726,685 |
| 1908(k) | (n) 39,120 | 607,950 | 63,551,057 | 1,212,184 | 1,463,557 | 19,786,734 | (n) 7,711,360 |
| 1909 | (n) 46,321 | 607,825 | (l) 64,089,132 | (l) 1,180,218 | (l) 1,479,142 | (l) 20,029,427 | (n) 7,276,050 |
| 1910 | 51,188 | 747,627 | 63,081,948 | 979,526 | 1,494,397 | 19,839,123 | (n) 8,398,405 |
| 1911 | 46,416 | 727,092 | 65,636,084 | 1,076,887 | 1,638,625 | 19,573,379 | £1,880,253 |
| 1912 | 41,989 | 656,460 | 65,479,346 | 1,042,489 | 1,590,557 | 18,584,946 | £2,252,305 |

| Year. | Copper. | | | | Iron. | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ingot. | Mixed or Yellow Metal. | Mfres | Sulphate. | Ore. | Pig. | Scrap. | Cast Iron and Mfres. | Wrought Iron, Shapes and Mfres |
| 1900 | 18,300 | 8,940 | 10,765 | 43,601 | (d) | (e) 1,450,365 | 96,567 | (b) | 159,677 |
| 1901 | 26,935 | 9,252 | 11,156 | 36,601 | (d) | (e) 852,609 | 86,559 | (b) | 119,962 |
| 1902 | 21,658 | 13,314 | 14,075 | 43,995 | 4,062 | 1,120,207 | 104,890 | (b) | (b) |
| 1903 | 23,723 | 14,425 | 16,975 | 54,307 | 4,534 | 1,082,426 | 143,929 | 62,249 | 217,139 |
| 1904 | 14,791 | 16,704 | 18,467 | 71,367 | 6,706 | 823,909 | 166,010 | 49,004 | 173,233 |
| 1905 | 21,232 | 9,959 | 22,128 | 55,219 | 14,664 | 997,601 | 151,619 | 49,193 | 186,340 |
| 1906 | 19,778 | 7,149 | 16,195 | 43,670 | 13,415 | 1,670,753 | 180,547 | 54,876 | 203,521 |
| 1907 | 25,652 | 7,994 | 16,676 | 46,049 | 15,538 | 1,978,350 | 162,295 | 43,218 | 215,159 |
| 1908(k) | 14,869 | 15,546 | 19,796 | (m) 72,429 | 4,478 | 1,317,330 | 135,115 | 48,336 | 174,539 |
| 1909 | 12,465 | (m) 11,381 | 17,248 | (m) 45,547 | (l) 5,185 | (l) 1,026,517 | (l) 165,183 | (l) 44,406 | (l) 171,698 |
| 1910 | 11,898 | (m) 15,970 | 12,551 | 43,391 | (l) 7,464 | (l) 1,062,444 | (l) 150,507 | (l) 57,148 | (q) 143,707 |
| 1911 | 10,970 | 15,101 | 24,669 | 81,112 | (l) 6,352 | 1,222,622 | 147,759 | (l) 70,618 | 140,312 |
| 1912 | 12,993 | 11,108 | 19,327 | 85,497 | 6,241 | 1,284,220 | 127,610 | 68,676 | 144,747 |

Iron. (*Continued.*)

| Year. | Rails. | Wire and Mfrs., of. | Plates and Sheets. | Galvanised Sheets. | Black Plates for Tinning. | Tinned Plates. | Steel Ingots, Billets, Blooms, etc. | Steel Shapes, Beams and Pillars. | Total Iron and Steel, and Mfrs. of. |
|---|---|---|---|---|---|---|---|---|---|
| 1900 | 379,939 | 39,104 | 39,157 | 251,203 | 66,810 | 278,338 | 313,383 | (b) | 3,602,083 |
| 1901 | 474,073 | 48,107 | 36,418 | 254,290 | 52,217 | 275,661 | 217,236 | (b) | 2,944,083 |
| 1902 | (b) | (b) | (b) | 336,572 | 58,245 | 317,201 | 306,152 | (b) | 3,529,225 |
| 1903 | 613,741 | 60,800 | 165,672 | 357,665 | 66,279 | 297,485 | 13,427 | 159,330 | 3,621,637 |
| 1904 | 533,895 | 61,894 | 154,774 | 391,608 | 63,467 | 365,262 | 4,324 | 176,232 | 3,315,049 |
| 1905 | 555,390 | 82,519 | 207,866 | 413,533 | 69,937 | 360,630 | 8,735 | 219,491 | 3,781,058 |
| 1906 | 470,652 | 96,641 | 279,459 | 450,221 | 66,749 | 381,421 | 11,924 | 311,231 | 4,763,868 |
| 1907 | 595,272 | 103,100 | 305,399 | 476,838 | 72,675 | 411,814 | 13,705 | 344,135 | 5,249,028 |
| 1908(k) | 589,525 | 95,801 | 210,526 | 396,366 | 62,079 | 409,335 | 2,452 | 278,792 | 4,162,065 |
| 1909 | (l) 589,499 | (l) 107,406 | (l) 169,918 | (l) 502,791 | (l) 61,025 | (l) 446,781 | (l) 3,217 | (l) 309,555 | 4,278,172 |
| 1910 | 490,068 | (l) 124,703 | (l) 197,858 | (l) 606,530 | (l) 56,691 | (l) 490,733 | (l) 3,340 | (q) 230,850 | 4,661,647 |
| 1911 | 381,320 | (l) 129,252 | (l) 203,850 | 627,215 | (l) 68,137 | 492,104 | (f) 4,376 | 231,793 | 4,588,385 |
| 1912 | 418,742 | 121,215 | 218,585 | 669,252 | 66,775 | 488,629 | 4,241 | 245,033 | 4,891,270 |

| Year. | Lead. Pig and Mfres. | Salt. | Sodium. | | | | Tin. Block | Zinc. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Soda Ash. | Carbonate and Bicarbonate. | Hydrate. | Sulphate. | | Ore. | Spelter. | Mfres. |
| 1900 .. | 36,576 | 556,704 | (*g*) 185,783 | (*h*) | (*h*) | (*h*) | 5,713 | 13,913 | 7,136 | 1,159 |
| 1901 .. | 38,166 | 627,078 | 58,412 | 22,161 | 50,624 | 26,057 | 5,584 | 13,981 | 7,512 | 1,256 |
| 1902 .. | 33,537 | 624,752 | 59,894 | 24,654 | 61,658 | 35,672 | 6,210 | 16,717 | 6,756 | 1,345 |
| 1903 .. | 36,152 | 594,300 | 58,605 | 23,574 | 59,725 | 45,630 | 6,349 | 15,659 | 8,192 | (*i*) |
| 1904 .. | 35,600 | 632,605 | 61,327 | 25,252 | 61,985 | 40,324 | 5,953 | 14,606 | 7,930 | (*i*) |
| 1905 .. | 42,265 | 588,389 | 67,678 | 28,425 | 68,675 | 33,681 | 7,741 | (*b*) | 7,451 | (*i*) |
| 1906 .. | 45,612 | 629,658 | 86,232 | 26,970 | 72,218 | 44,448 | 8,631 | (*b*) | 7,962 | (*i*) |
| 1907 .. | 44,068 | 592,989 | 91,120 | 29,539 | 70,432 | 45,898 | 8,808 | 11,511 | 6,666 | (*i*) |
| 1908 (*k*) | 50,221 | 532,101 | (*n*) 83,713 | (*n*) 20,805 | (*n*) 73,769 | (*n*) 22,974 | 9,486 | 3,833 | 8,537 | (*i*) |
| 1909 .. | (*m*) 46,399 | 523,690 | (*n*) 97,480 | (*n*) 23,378 | (*n*) 80,439 | (*n*) 35,587 | 11,373 | (*b*) | (*m*) 8,684 | (*i*) |
| 1910 .. | 47,588 | 571,845 | 110,188 | 23,295 | 84,291 | 58,960 | 12,576 | (*b*) | 9,247 | (*i*) |
| 1911 .. | 44,733 | 614,572 | 125,945 | 26,353 | 82,356 | 59,382 | 11,736 | (*b*) | 9,736 | (*i*) |
| 1912 .. | 47,782 | 557,291 | 144,073 | 29,403 | 79,527 | 50,759 | 12,152 | (*b*) | 10,881 | ..... |

(*a*) From *Accounts Relating to Trade and Navigation of the United Kingdom.* (*b*) Not reported. (*c*) Including naphtha, paraffin, paraffin oil and petroleum. (*d*) Previous reports not available. (*e*) Includes puddled iron. (*f*) Includes railroad material of all kinds. (*g*) Includes all soda compounds; not separate; enumerated previous to 1901. (*h*) Included under soda ash. (*i*) Included under spelter. (*k*) From *Mines and Quarries.* (*l*) From *Iron and Coal Trades Review.* (*m*) *Mining Journal.* (*n*) From *Oil Paint and Drug Reporter.* (*q*) Bars only.

# UNITED STATES

Of the following tables, the first records the imports of foreign mineral and metal products into the United States, whether dutiable or duty free; the second shows the exports of materials produced in the United States: and the third reports the re-exports of products of foreign origin. These statistics are as reported by the Bureau of Statistics of the Department of Commerce and Labor, and special acknowledgment is due to A. H. Baldwin, chief of the bureau, for furnishing the figures for many substances which are not reported in the Monthly Summary. The complete statement of production in the United States is given on an early page in this volume.

IMPORTS. (a)

| Year. | Aluminum. Crude. Lb. | Kg. | Value. | Value per Lb. | Ammonium Sulphate. Lb. | Metric Tons. | Value. | Value per Lb. |
|---|---|---|---|---|---|---|---|---|
| 1903 | 498,655 | 226,190 | $139,298 | $0.279 | 29,104,817 | 13,199 | $565,230 | $0.026 |
| 1904 | 515,416 | 234,293 | 128,350 | 0.249 | 39,859,690 | 18,077 | 1,058,981 | 0.027 |
| 1905 | 530,429 | 240,284 | 106,108 | 0.200 | 15,512,399 | 7,038 | 416,048 | 0.027 |
| 1906 | 770,713 | 349,195 | 154,292 | 0.200 | 31,797,291 | 14,423 | 894,663 | 0.028 |
| 1907 | 872,474 | 395,754 | 181,352 | 0.208 | 70,440,992 | 31,960 | 1,828,236 | 0.026 |
| 1908 | 465,317 | 210,785 | 80,268 | 0.173 | 76,475,104 | 34,698 | 1,982,830 | 0.026 |
| 1909 | 5,109,843 | 2,317,784 | 745,963 | 0.145 | 85,829,334 | 38,932 | 2,114,694 | 0.024 |
| 1910 | (a)12,271,277 | 5,567,730 | 1,844,830 | 0.151 | 184,686,534 | 83,795 | 4,668,820 | 0.025 |
| 1911 | 4,173,308 | 1,893,000 | 598,272 | 0.143 | 189,265,797 | 85,850 | 5,066,470 | 0.027 |
| 1912 | 22,759,937 | 10,323,839 | 3,032,889 | 0.136 | 119,084,402 | 54,016 | 3,447,225 | 0.029 |

| Year. | Antimony. (r) Lb. | Metric Tons. | Value. | Value per Lb. | Antimony Ore. Lb. | Metric Tons. | Value. | Value per Lb. |
|---|---|---|---|---|---|---|---|---|
| 1903 | 5,125,515 | 2,325 | $279,957 | $0.054 | 2,673,142 | 1,213 | $51,489 | $0.019 |
| 1904 | 4,056,299 | 1,840 | 235,401 | 0.058 | 2,487,602 | 1,129 | 50,362 | 0.020 |
| 1905 | 5,737,891 | 2,603 | 431,774 | 0.075 | 1,976,694 | 897 | 52,868 | 0.027 |
| 1906 | 7,900,194 | 3,583 | 1,417,816 | 0.179 | 2,247,131 | 1,019 | 128,347 | 0.057 |
| 1907 | 8,662,683 | 3,928 | 1,423,276 | 0.164 | 2,780,186 | 1,261 | 180,903 | 0.065 |
| 1908 | 8,114,651 | 3,954 | 572,979 | 0.071 | 3,280,922 | 1,488 | 106,930 | 0.033 |
| 1909 | 9,652,568 | 4,335 | 619,179 | 0.064 | 3,386,708 | 1,575 | 94,249 | 0.027 |
| 1910 | 9,899,514 | 4,487 | 572,031 | 0.058 | *Nil.* | ..... | ..... | ..... |
| 1911 | 10,957,844 | 4,970 | 573,564 | 0.052 | *Nil.* | ..... | ..... | ..... |
| 1912 | 17,645,870 | 8,004 | 936,920 | 0.053 | *Nil.* | ..... | ..... | ..... |

| Year. | Asbestos. Crude Value. | Mfd. Value. | Total Value. | Asphaltum. Long Tons. | Metric Tons. | Value. | Value per L. T. |
|---|---|---|---|---|---|---|---|
| 1903 | $657,269 | $32,058 | $689,327 | 167,554 | 170,235 | $514,051 | $3.06 |
| 1904 | 700,572 | 51,290 | 751,862 | 119,575 | 121,489 | 510,524 | 4.27 |
| 1905 | 776,362 | 70,117 | 846,749 | 86,748 | 88,136 | 382,667 | 4.41 |
| 1906 | 536,500 | ..... | ..... | 97,274 | 98,830 | 388,010 | 3.93 |
| 1907 | 1,104,109 | 200,371 | 1,304,480 | 127,902 | 129,948 | 518,074 | 4.05 |
| 1908 | 1,068,342 | 147,548 | 1,215,869 | 131,862 | 133,971 | 587,698 | 4.45 |
| 1909 | 993,254 | 240,381 | 1,233,635 | 132,807 | 134,939 | 646,655 | 4.87 |
| 1910 | 1,235,170 | 308,078 | 1,543,248 | 166,379 | 169,041 | 776,283 | 4.66 |
| 1911 | 1,413,541 | 161,442 | 1,574,983 | 174,234 | 177,030 | 778,185 | 4.47 |
| 1912 | 1,456,012 | 363,759 | 1,819,771 | 194,775 | 197,901 | 919,467 | 4.72 |

| Year. | Arsenic.(*b*) | | | | Barytes. | | | | Bauxite. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lb. | Metric Tons. | Value. | Value per Lb. | Long Tons. | Metric Tons. | Value. | Value per L. T. | Long Tons. | Metric Tons. | Value. | Value per L. T. |
| 1903.... | 7,391,566 | 3,241 | $256,097 | $0.036 | 6,344 | 6,446 | $22,777 | $3.59 | 14,889 | 15,127 | $49,684 | $3.34 |
| 1904.... | 6,391,566 | 2,900 | 226,481 | 0.036 | 6,689 | 6,796 | 27,463 | 4,11 | 15,475 | 15,723 | 49.577 | 3.20 |
| 1905.... | 6,444,083 | 2,924 | 219,198 | 0,034 | 7,879 | 8,005 | 36,796 | 4.67 | 11,726 | 11,914 | 46,517 | 3.96 |
| 1906.... | 7,639,507 | 3,464 | 336,609 | 0.044 | 4,293 | 4,362 | 37,296 | 8.69 | 17,809 | 18,094 | 63,221 | 3.55 |
| 1907.... | 9,922,870 | 4,500 | 553,440 | 0.056 | 28,350 | 28,804 | 174,225 | 6.15 | 25,065 | 25,466 | 93,208 | 3.72 |
| 1908.... | 9,592,881 | 4,558 | 417,137 | 0.056 | *n*)12,196 | 12,390 | 58,822 | 4.83 | 21,679 | 22,033 | 87,823 | 4,05 |
| 1909.... | 7,183,644 | 3,259 | 272,493 | 0.038 | *n*)13,091 | 13,301 | 54,707 | 4.19 | 18,989 | 18,689 | 83,956 | 4.49 |
| 1910.... | 8,257,474 | 3,745 | 251,716 | 0.031 | *n*)16,960 | 17,226 | 48,457 | 2.86 | 14,038 | 14,258 | 65,743 | 4.68 |
| 1911.... | 5,404,263 | 2,451 | 159,626 | 0.030 | 20,860 | 21,195 | 58,726 | 2.82 | 43,222 | 43,916 | 164,301 | 3.80 |
| 1912.... | 6,758,946 | 3,066 | 246,815 | 0,037 | 26,665 | 27,093 | 79,315 | 2.97 | 26,214 | 26,635 | 95,431 | 3.64 |

| Year. | Bismuth. | | | | Chrome Ore. | | | | Coal, Anthracite. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lb. | Kg. | Value. | Value per Lb. | Long Tons. | Metric Tons. | Value. | Value per L.T. | Long Tons. | Metric Tons. | Value | Value per L.T. |
| 1903 . | 147,324 | 66,826 | $235,199 | $1.59 | 22,932 | 23,299 | $302,025 | $13.17 | 151,023 | 153,439 | $675,623 | $4.47 |
| 1904 . | 147,712 | 67,002 | 268,837 | 1.82 | 24,227 | 24,615 | 348,527 | 14.38 | 72,526 | 73,686 | 220,665 | 3.04 |
| 1905 . | 148,589 | 67,459 | 318,007 | 2.14 | 54,434 | 55,305 | 725,301 | 13.32 | 34,262 | 34,810 | 107,394 | 3.13 |
| 1906 . | 254,733 | 115,000 | 318,452 | 1.25 | 43,441 | 44,136 | 557,594 | 12.84 | 32,357 | 32,875 | 105,190 | 3.25 |
| 1907 . | 259,881 | 117,882 | 325,015 | 1.25 | 41,999 | 42,671 | 491,925 | 11.71 | 9,896 | 10,054 | 40,966 | 4.14 |
| 1908 . | 164,793 | 73,002 | 257,397 | 1.56 | 27,876 | 28,320 | 345,960 | 12.40 | 16,483 | 16,747 | 73,777 | 4.47 |
| 1909 . | 183,413 | 83,195 | 286,516 | 1.56 | 39,820 | 40,459 | 460,758 | 11.57 | 4,709 | 4,785 | 19,438 | 4.13 |
| 1910 . | 198,174 | 89,916 | 332,674 | 1.67 | 38,579 | 39,196 | 415,768 | 10.77 | 8,196 | 8,327 | 42,234 | 5.14 |
| 1911 . | 172,093 | 78,061 | 311,771 | 1.81 | 37,529 | 38,131 | 407,958 | 10.87 | 2,463 | 2,502 | 12,550 | 5.10 |
| 1912 . | 182,839 | 82,935 | 316'440 | 1.73 | 53,929 | 54 795 | 499 818 | 9,27 | 1,670 | 1,697 | 8,329 | 4,99 |

| Year. | Chloride of Lime. | | | | Cement. | | | |
|---|---|---|---|---|---|---|---|---|
| | Lb. | Metric Tons. | Value. | Value per Lb. | Barrels. (*c*) | Metric Tons. | Value. | Value. per Bbl. |
| 1903..... | 113,285,240 | 51,586 | $912,843 | $0.008 | 2,317,951 | 420,569 | $3,027,111 | $ 1.30 |
| 1904..... | 87,909,168 | 39,876 | 707,174 | 0.008 | 1,046,404 | 189,910 | 1,382,913 | 1.32 |
| 1905..... | 104,919,462 | 47,604 | 843,285 | 0.008 | 846,577 | 153,644 | 1,102,041 | 1.30 |
| 1906..... | 105,221,371 | 47,718 | 863,490 | 0.008 | 2,205,712 | 400,115 | 2,950,268 | 1.33 |
| 1907..... | 112,090,783 | 50,833 | 939,248 | 0.008 | 2,006,228 | 363,929 | 2,637,424 | 1.31 |
| 1908..... | 74,602,059 | 33,848 | 621,713 | 0.008 | 839,246 | 152,313 | 1,189,560 | 1.42 |
| 1909..... | 91,390,004 | 41,454 | 743,636 | 0.008 | 431,785 | 78,342 | 642,397 | 1.49 |
| 1910..... | 101,029,345 | 45,839 | 797,260 | 0.008 | 292,314 | 53,053 | 396,428 | 1.36 |
| 1911..... | 82,895,472 | 37,601 | 667,804 | 0.008 | 163,802 | 29,720 | 254,258 | 1.55 |
| 1912..... | 74,235,256 | 33,673 | 597,002 | 0.008 | 65,064 | 11,805 | 93,583 | 1.44 |

| Year. | Coal, Bituminous. | | | | Total Coal. | | Coke. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Long Tons. | Metric Tons | Value. | Value per L.T. | Long Tons. | Value. | Long Tons. | Metric Tons. | Value. | Value per L.T. |
| 1903.... | 3,295,379 | 3,348,105 | $9,329,221 | $2.83 | 3,446,402 | $10,004,844 | 127,479 | 129,519 | $437,625 | $3.43 |
| 1904.... | 1,556,149 | 1,581,047 | 3,915,613 | 2.52 | 1,628 675 | 4,136,278 | 161,476 | 164,060 | 648,520 | 4.01 |
| 1905.... | 1,618,581 | 1,644,478 | 3,908,877 | 2.42 | 1,652,843 | 4,016,271 | 181,376 | 184,278 | 796,544 | 4.39 |
| 1906.... | 1,712,150 | 1,739,544 | 4,129,555 | 2.41 | 1,744,507 | 4,234,745 | 114,703 | 116,538 | 558,419 | 4.87 |
| 1907.... | 2,116,122 | 2,149,980 | 5,398,167 | 2.55 | 2,126,018 | 5,439,133 | 132,536 | 134,656 | 594,137 | 4.48 |
| 1908.... | 1,487,816 | 1,511,621 | 4,059,786 | 2.73 | 1,504,299 | 4,133,563 | 129,591 | 131,624 | 603,964 | 4.65 |
| 1909.... | 1,257,629 | 1,277,814 | 3,597,991 | 2.56 | 1,262,338 | 3,617,429 | 170,671 | 173,410 | 735,253 | 4.31 |
| 1910.... | 1,991,943 | 2,023,914 | 5,381,062 | 2.69 | 2,000,270 | 5,423,296 | 156,417 | 158,920 | 625,619 | 4.00 |
| 1911.... | 1,238,808 | 1,258,691 | 3,611,518 | 2.92 | 1,241,271 | 3,624,068 | 69,515 | 70,631 | 254,938 | 3.67 |
| 1912.... | 1,610,020 | 1,635,861 | 4,516,965 | 2.81 | 3,218,370 | 9,027,601 | 110,347 | 112,118 | 488,691 | 4.43 |

| Year. | Cobalt Oxide. | | | | Copper, Ore and Matte. | | | |
|---|---|---|---|---|---|---|---|---|
| | Lb. | Kg. | Value. | Value per Lb. | Long Tons. | Metric Tons. | Value. | Value per L. T. |
| 1903..... | 73,350 | 33,272 | $145,264 | $1.98 | 284,912 | 289,471 | $3,177,582 | $11.15 |
| 1904..... | 42,352 | 19,211 | 86,925 | 2.05 | 268,234 | 272,527 | 4,308,410 | 16.06 |
| 1905..... | 70,048 | 31,802 | 139,377 | 1.99 | 296,251 | 300,991 | 5,765,238 | 19.46 |
| 1906..... | 41,084 | 18,652 | 83,167 | 2.02 | 208,702 | 212,041 | 6,796,696 | 32.56 |
| 1907..... | 42,794 | 19,421 | 73,028 | 1.71 | 291,957 | 297,096 | 9,048,270 | 31.32 |
| 1908..... | 1,550 | 701 | 3,095 | 2.00 | 288,022 | 292,630 | 6,978,513 | 24.20 |
| 1909..... | 9,818 | 4,453 | 11,065 | 1.132 | 393,530 | 399,846 | 9,113,254 | 23.16 |
| 1910..... | 6,124 | 2,778 | 4,806 | 0.785 | 453,747 | 461,007 | 9,182,161 | 20.23 |
| 1911..... | 22,934 | 10,403 | 11,047 | 0.482 | 292,931 | 297,633 | 6,935,794 | 23.68 |
| 1912..... | 31,848 | 14,446 | 15,132 | 0.475 | 499,549 | 507,567 | 12,696,532 | 25.42 |

| Year. | Copper, Ingots, Old, etc. | | | | Cryolite. | | | |
|---|---|---|---|---|---|---|---|---|
| | Lb. | Metric. Tons. | Value. | Value. per Lb. | Long Tons. | Metric Tons. | Value. | Value. per L. T. |
| 1903..... | 136,707,995 | 62,011 | $17,262,148 | $0.126 | 7,708 | 7,831 | $102,879 | $13.35 |
| 1904..... | 142,344,433 | 64,567 | 18,374,959 | 0.129 | 959 | 974 | 13,708 | 14.30 |
| 1905..... | 160,619,385 | 72,876 | 22,103,741 | 0.137 | 1,600 | 1,623 | 22,482 | 14.05 |
| 1906..... | 176,558,390 | 80,069 | 30,416,578 | 0.172 | 1,505 | 1,529 | 29,683 | 19.72 |
| 1907..... | 192,901,267 | 87,523 | 38,658,754 | 0.200 | 1,438 | 1,461 | 28,920 | 20.10 |
| 1908..... | 162,224,144 | 73,604 | 22,851,134 | 0.141 | 1,124 | 1,142 | 16,445 | 14.63 |
| 1909..... | 240,713,721 | 109,186 | 30,529,425 | 0.127 | 1,278 | 1,299 | 18,427 | 14.42 |
| 1910..... | 259,210,796 | 117,609 | 31,620,689 | 0.122 | 36 | ..... | 2,343 | ..... |
| 1911..... | 265,940,760 | 120,630 | 31,540,827 | 0.119 | 2,007 | 2,039 | 47,093 | 23.46 |
| 1912..... | 305,369,592 | 138,515 | 44,259,727 | 0.145 | 2,126 | 2,160 | 48,293 | 22.72 |

| Year. | Emery Grains. | | | | Emery Rock. | | | |
|---|---|---|---|---|---|---|---|---|
| | Lb. | Metric. Tons. | Value. | Value per Lb. | Long Tons. | Metric. Tons. | Value. | Value per L. T. |
| 1903.... | 3,595,239 | 1,630 | $109,272 | $0.030 | 10,885 | 11,059 | $188,985 | $17.36 |
| 1904.... | 2,281,193 | 1,035 | 109,772 | 0.048 | 7,054 | 7,167 | 131,493 | 18.64 |
| 1905.... | 3,209,915 | 1,456 | 143,729 | 0.045 | 11,073 | 11,250 | 185,689 | 16.77 |
| 1906.... | 4,655,168 | 2,113 | 215,357 | 0.043 | 13,840 | 14,061 | 286,386 | 20.69 |
| 1907.... | 4,282,228 | 1,942 | 186,156 | 0.043 | 11,235 | 11,415 | 211,184 | 18.80 |
| 1908.... | 1,735,366 | 788 | 89,702 | 0.052 | 8,084 | 8,213 | 146,105 | 18.09 |
| 1909.... | 2,696,960 | 1,224 | 132,264 | 0.049 | 9,836 | 9,993 | 186,930 | 19.00 |
| 1910.... | 1,189,664 | 535 | 53,709 | 0.045 | 16,770 | 16,321 | 344,421 | 20.54 |
| 1911.... | 712,134 | 323 | 35,384 | 0.050 | 10,232 | 10,396 | 176,890 | 17.29 |
| 1912.... | 791,667 | 359 | 32,876 | 0.042 | 15,793 | 16,052 | 284,585 | 18.01 |

| Year. | Fuller's Earth. | | Gold. | | Iron Ore. | | | |
|---|---|---|---|---|---|---|---|---|
| | Long Tons. | Value. | In Coin and Bullion. | In Ore. | Long Tons. | Metric Tons. | Value. | Value per L. T. |
| 1903... | 15,267 | $120,671 | $44,054,902 | $21,212,794 | 980,440 | 996,127 | $2,261,008 | $2.31 |
| 1904... | 9,126 | 78,006 | 75,646,128 | 9,157,106 | 487,613 | 495,415 | 1,101,384 | 2.26 |
| 1905... | 13,001 | 105,997 | 38,564,328 | 11,729,077 | 845,651 | 859,181 | 2,062,161 | 2.44 |
| 1906... | 13,238 | 108,696 | 139,705,887 | 15,873,493 | 1,060,390 | 1,007,356 | 2,967,434 | 2.80 |
| 1907... | 14,648 | 122,221 | 130,605,413 | 12,792,659 | 1,229,168 | 1,248,835 | 3,937,483 | 3.20 |
| 1908... | 10,963 | 92,413 | 38,346,267 | 11,930,026 | 776,898 | 789,326 | 2,224,248 | 2.86 |
| 1909... | 11,406 | 101,151 | 30,648,147 | 13,438,819 | 1,694,957 | 1,722,161 | 4,579,078 | 2.70 |
| 1910... | 13,775 | 132,545 | 47,212,754 | 12,009,764 | 2,591,031 | 2,632,617 | 7,832,225 | 3.02 |
| 1911... | 16,272 | 143,594 | 46,623,766 | 10,821,418 | 1,811,732 | 1,840,810 | 5,412,636 | 2.99 |
| 1912... | 17,062 | ,145,337 | 55,789,406 | 10,758,866 | 2,104,576 | 2,138,354 | 6,499,690 | 3.09 |

| Year. | Phosphates, Crude. | | | | Pig Iron. | | | |
|---|---|---|---|---|---|---|---|---|
| | Long Tons. | Metric. Tons. | Value. | Value per L. T. | Long Tons. | Metric Tons. | Value. | Value per L. T. |
| 1903.... | 132,965 | 134,092 | $679,112 | $5.11 | 599,574 | 609,167 | $11,173,302 | $18.64 |
| 1904.... | 130,214 | 132,297 | 745,744 | 5.73 | 79,590 | 80,772 | 1,765,107 | 22.20 |
| 1905.... | 56,021 | 56,917 | 273,289 | 4.88 | 212,465 | 215,864 | 5,185,784 | 24.41 |
| 1906.... | 23,281 | 23,653 | 147,547 | 6.34 | 379,828 | 385,905 | 11,851,210 | 31.20 |
| 1907.... | 25,876 | 26,290 | 163,944 | 6.34 | 489,475 | 497,305 | 13,418,982 | 27.42 |
| 1908.... | 26,734 | 27,161 | 175,365 | 6.56 | 92,202 | 93,677 | 2,886,339 | 31.35 |
| 1909.... | 11,903 | 12,094 | 97,277 | 8.18 | 176,442 | 179,265 | 5,112,045 | 28.97 |
| 1910.... | 19,384 | 19,688 | 235,040 | 12.12 | 237,233 | 241,029 | 6,549,938 | 27.61 |
| 1911.... | 16,153 | 16,412 | 157,394 | 9.74 | 148,459 | 150,842 | 4,380,334 | 29.50 |
| 1912.... | 28,821 | 29,284 | 231,255 | 8.02 | 129,325 | 131,401 | 4,770,730 | 36.89 |

| Year. | Scrap, Iron and Steel. | | | Bar Iron. | | |
|---|---|---|---|---|---|---|
| | Long Tons. | Metric Tons. | Value. | Long Tons. | Metric Tons. | Value. |
| 1903..... | 82,921 | 84,248 | $1,273,941 | 43,392 | 44,090 | $1,904,469 |
| 1904..... | 13,461 | 13,676 | 189,506 | 20,905 | 21,247 | 917,254 |
| 1905..... | 23,731 | 24,111 | 370,328 | 37,294 | 37,891 | 1,522,434 |
| 1906..... | 19,091 | 19,397 | 248,106 | 35,793 | 36,366 | 1,590,592 |
| 1907..... | 27,652 | 28,094 | 368,842 | 39,746 | 40,382 | 1,774,441 |
| 1908..... | 5,090 | 5,171 | 61,981 | 19,671 | 19,980 | 837,585 |
| 1909..... | 63,504 | 64,523 | 781,426 | 19,210 | 19,518 | 806,862 |
| 1910..... | 72,764 | 73,928 | 928,002 | 38,231 | 38,783 | 1,565,999 |
| 1911..... | 17,272 | 17,549 | 190,285 | 26,730 | 27,159 | 1,202,363 |
| 1912..... | 23,612 | 23,991 | 256,710 | 26,112 | 26,531 | 1,151,853 |

| Year. | Rails. | | | Hoop, Band or Scroll. | | | Ingots, Blooms, Slabs, Billets, etc. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Long Tons. | Metric Tons. | Value. | Long Tons. | Metric Tons. | Value. | Long Tons. | Metric Tons. | Value. |
| 1903... | 95,555 | 97,083 | $2,159,273 | 1,525 | 1,550 | $74,598 | 261,570 | 265,932 | $7,331,299 |
| 1904... | 37,776 | 38,380 | 808,775 | 2,135 | 2,169 | 60,934 | (*m*)10,807 | 10,980 | 1,537,531 |
| 1905... | 17,278 | 17,554 | 409,807 | 4,772 | 4,848 | 137,612 | (*m*)14,641 | 14,875 | 2,072,606 |
| 1906... | 4,943 | 5,022 | 137,104 | 10,231 | 10,395 | 256,836 | (*m*)21,337 | 21,678 | 3,010,589 |
| 1907... | 3,752 | 3,812 | 104,958 | 1,508 | 1,532 | 82,706 | (*m*)19,334 | 19,643 | 3,004,178 |
| 1908... | 1,719 | 1,752 | 53,128 | 1,110 | 1,127 | 75,920 | 11,212 | 11,391 | 1,437,514 |
| 1909... | 1,542 | 1,567 | 36,963 | (*n*) | (*n*) | (*n*) | 19,289 | 19,599 | 2,695,630 |
| 1910... | (*n*) | (*n*) | (*n*) | (*n*) | (*n*) | (*n*) | 46,578 | 47,323 | 4,075,036 |
| 1911... | (*n*) | (*n*) | (*n*) | (*n*) | (*n*) | (*n*) | 29,205 | 29,687 | 2,772,614 |
| 1912. | 3,780 | 3,841 | 101,544 | (*n*) | (*n*) | (*n*) | 18,702 | 19,002 | 2,941,431 |

| Year. | Sheet, Plate and Taggers Iron or Steel. | | | Tin Plates, Terne Plates and Taggers Tin. | | | Wire Rods. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Long Tons. | Metric Tons. | Value. | Long Tons. | Metric Tons. | Value. | Long Tons. | Metric Tons. | Value. |
| 1903... | 11,557 | 11,741 | $540,272 | 47,360 | 48,118 | $2,999,252 | 20,836 | 21,169 | $1,028,977 |
| 1904... | 4,165 | 4,232 | 302,500 | 70,652 | 71,782 | 4,354,761 | 15,313 | 15,558 | 707,779 |
| 1905... | 2,236 | 2,272 | 242,955 | 65,740 | 66,792 | 4,090,523 | 17,616 | 17,898 | 800,027 |
| 1906... | 3,231 | 3,283 | 325,276 | 56,982 | 57,894 | 3,883,225 | 17,799 | 18,084 | 876,270 |
| 1907... | 3,749 | 3,809 | 367,140 | 57,773 | 58,697 | 4,462,522 | 17,076 | 17,349 | 851,571 |
| 1908... | 2,628 | 2,669 | 377,549 | 58,492 | 59,426 | 3,651,576 | 11,208 | 11,387 | 543,170 |
| 1909... | 4,711 | 4,787 | 536,841 | 62,593 | 63,598 | 3,782,952 | 10,544 | 10,613 | 531,652 |
| 1910... | 6,107 | 6,205 | 461,632 | 67,086 | 68,159 | 4,502,862 | 20,374 | 20,700 | 1,024,831 |
| 1911... | 2,492 | 2,532 | 274,945 | 14,089 | 14,324 | 1,082,417 | 15,483 | 15,980 | 731,291 |
| 1912... | 3,300 | 3,353 | 363,694 | 2,052 | 2,085 | 229,338 | 15,069 | 15,311 | 726,205 |

| Year. | Wire and Articles Made from. | | | Total Iron Imports. (e) | Lead in Ore and Base Bullion. | | |
|---|---|---|---|---|---|---|---|
| | Long Tons. | Metric Tons. | Value. | | Short Tons. | Metric Tons | Value. |
| 1903 | 5,018 | 5,098 | $728,430 | 41,258,864 | 103,384 | 93,790 | $3,596,635 |
| 1904 | 3,956 | 4,019 | 624,892 | 21,621,970 | 104,127 | 94,464 | 3,517,691 |
| 1905 | 3,978 | 4,042 | 705,465 | 26,401,283 | 92,657 | 84,081 | 3,565,282 |
| 1906 | 6,610 | 6,716 | 1,079,868 | 34,827,132 | 72,371 | 65,640 | 3,490,750 |
| 1907 | (d) | (d) | 1,551,415 | 38,789,992 | 70,538 | 64,019 | 3,579,990 |
| 1908 | (d) | (d) | 1,003,973 | 19,957,385 | 109,315 | 99,168 | 4,384,904 |
| 1909 | (d) | (d) | 1,117,812 | 30,571,542 | 110,605 | 100,339 | 4,121,380 |
| 1910 | (d) | (d) | 1,468,741 | 47,115,112 | 105,117 | 106,805 | 4,056,722 |
| 1911 | (d) | (d) | 1,270,426 | 28,995,600 | 87,319 | 79,215 | 3,452,695 |
| 1912 | (d) | (d) | 1,103,192 | 29,328,709 | 83,288 | 75,558 | 3,721,583 |

| Year. | Lead in Pigs and Old. | | | Lead, Sheet, Pipe, Shot, etc. | | | Other Lead Mfres. | Total Lead. |
|---|---|---|---|---|---|---|---|---|
| | Short Tons. | Metric Tons. | Value. | Lb. | Metric Tons. | Value. | | |
| 1903 | 3,023 | 2,742 | $164,528 | 17,008 | 8 | 10 | $8,071 | $3,770,044 |
| 1904 | 8,724 | 7,914 | 461,316 | 69,581 | 32 | 41 | 7,755 | 3,989,203 |
| 1905 | 5,720 | 5,812 | 367,106 | 54,779 | 25 | 38 | 4,580 | 3,939,606 |
| 1906 | 11,763 | 10,669 | 910,417 | 346,177 | 157 | 50 | 20,681 | 4,401,167 |
| 1907 | 9,277 | 8,414 | 846,166 | 734,418 | 333 | 10 | 12,736 | 4,426,156 |
| 1908 | 2,759 | 2,504 | 182,503 | 42,376 | 19 | 26 | 46,486 | 4,567,407 |
| 1909 | 3,576 | 3,244 | 230,347 | 40,434 | 18 | 56 | 33,892 | 4,351,727 |
| 1910 | 3,491 | 3,166 | 202,376 | (f) | ..... | .... | 7,073 | 4,259,098 |
| 1911 | 2,632 | 2,388 | 190,543 | (f) | ..... | .... | 9,834 | 3,642,238 |
| 1912 | 272 | 247 | 19,917 | 31,284 | 14 | 05 | 5,023 | 3,748,828 |

| Year. | White Lead. | | | | Litharge. | | | | Red Lead. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lb. | Metric Tons. | Value. | Value per lb. | Lb. | Metric Tons. | Value. | Value per lb. | Lb. | Metric Tons. | Value. | Value per lb. |
| 1903 | 453,284 | 206 | $24,595 | $0.054 | 42,756 | 19 | $1,464 | $0.034 | 1,152,715 | 523 | $40,846 | $0.035 |
| 1904 | 587,338 | 266 | 33,788 | 0.058 | 44,541 | 20 | 1,500 | 0.034 | 836,077 | 379 | 30,115 | 0.036 |
| 1905 | 597,510 | 271 | 34,722 | 0.058 | 117,757 | 53 | 4,139 | 0.035 | 704,402 | 320 | 26,553 | 0.038 |
| 1906 | 647,636 | 294 | 41,233 | 0.064 | 87,230 | 40 | 3,737 | 0.043 | 1,093,619 | 497 | 50,741 | 0.046 |
| 1907 | 584,309 | 265 | 37,482 | 0.064 | 90,475 | 41 | 4,386 | 0.048 | 679,171 | 308 | 35,959 | 0.053 |
| 1908 | 540,311 | 245 | 30,451 | 0.056 | 96,184 | 44 | 3,327 | 0.035 | 645,073 | 292 | 28,155 | 0.034 |
| 1909 | 694,599 | 315 | 39,963 | 0.057 | 90,655 | 32 | 3,740 | 0.041 | 760,179 | 345 | 30,428 | 0.040 |
| 1910 | 686,052 | 311 | 38,919 | 0.057 | 48,693 | 22 | 2,252 | 0.046 | 822,289 | 373 | 32,750 | 0.039 |
| 1911 | 741,071 | 336 | 46,213 | 0.062 | 24,662 | 11 | 1,196 | 0.048 | 1,163,533 | 528 | 46,170 | 0.040 |
| 1912 | 687,705 | 312 | 46,494 | 0.068 | 32,443 | 15 | 1,550 | 0.048 | 757,908 | 344 | 33,854 | 0.045 |

| Year. | Orange Mineral. | | | | Magnesite. | | | |
|---|---|---|---|---|---|---|---|---|
| | Lb. | Metric Tons. | Value. | Value per Lb. | Long Tons. | Metric Tons. | Value. | Value. per L.T. |
| 1903 | 756,742 | 343 | $36,407 | $0.048 | 49,684 | 50,479 | $461,399 | $9.29 |
| 1904 | 766,469 | 348 | 37,178 | 0.049 | 35,106 | 35,668 | 286,828 | 8.17 |
| 1905 | 628,003 | 285 | 31,106 | 0.049 | 66,405 | 67,566 | 638,619 | 9.46 |
| 1906 | 770,342 | 350 | 42,519 | 0.055 | 80,711 | 82,002 | 863,492 | 10.70 |
| 1907 | 615,015 | 279 | 37,793 | 0.061 | 88,400 | 89,814 | 875,359 | 9.90 |
| 1908 | 485,407 | 220 | 26,645 | 0.055 | 75,442 | 76,648 | 736,763 | 9.80 |
| 1909 | 496,231 | 225 | 27,562 | 0.056 | 102,045 | 103,683 | 985,019 | 9.66 |
| 1910 | 600,461 | 269 | 32,199 | 0.053 | 152,078 | 154,511 | 1,542,800 | 10.14 |
| 1911 | 504,734 | 229 | 28,515 | 0.056 | 120,133 | 122,061 | 1,185,867 | 9.85 |
| 1912 | 334,551 | 152 | 20,914 | 0.063 | 123,801 | 125,788 | 1,369,665 | 11.06 |

| Year. | Manganese Ore. | | | | Mica. | Nickel. (h) | Nickel Ore and Matte. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Long Tons. | Metric Tons. | Value. | Value per L. T. | | | Long Tons. | Metric Tons. | Value. |
| 03..... | 146,056 | 148,393 | $1,278,108 | $8.75 | $317,969 | $207,954 | 11,936 | 16,191 | $1,285,935 |
| 04..... | 108,519 | 110,255 | 901,592 | 8.31 | 269,808 | 206,021 | 8,549 | 8,685 | 915,470 |
| 05..... | 257,033 | 261,146 | 1,952,407 | 7.60 | 403,755 | 335,211 | 13,451 | 13,666 | 1,626,920 |
| 06..... | 221,260 | 224,800 | 1,696,043 | 7.67 | 1,042,608 | 86,336 | 15,156 | 15,398 | 1,816,631 |
| 07..... | 209,021 | 211,236 | 1,793,143 | 8.59 | 915,259 | 90,153 | 16,888 | 17,158 | 2,153,971 |
| 08..... | 178,023 | 181,054 | 1,350,223 | 7.59 | 264,755 | 101,398 | 16,322 | 16,582 | 2,396,217 |
| 09..... | 212,765 | 216,180 | 1,405,329 | 6.60 | 493,978 | 104,019 | 18,578 | 18,876 | 2,927,975 |
| 10..... | 242,348 | 246,226 | 1,711,131 | 7.06 | 721,541 | 139,772 | 28,519 | 28,975 | 4,085,076 |
| 11..... | 176,852 | 179,690 | 1,186,791 | 6.71 | 469,089 | 104,160 | 23,993 | 24,378 | 3,918,556 |
| 12..... | 300,661 | 305,487 | 1,769,184 | 5.84 | 745,399 | 120,511 | 33,101 | 33,632 | 5,638,456 |

| Year. | Oil, Mineral. | | | Platinum, Unmanufactured. | | | | Platinum Mfrs. |
|---|---|---|---|---|---|---|---|---|
| | Gal. | Value | Value per Gal. | Lb. Troy. | Kg. | Value. | Value per Lb. Troy. | |
| 03.... | 4,266,974 | $261,199 | $0.061 | 9,540 | 3,561 | $1,921,772 | $201.44 | 1,727,830 |
| 04.... | 4,846,681 | 277,399 | 0.057 | 8,648 | 3,230 | 1,812,242 | 209.55 | 105,636 |
| 05.... | 13,725,720 | 672,127 | 0.049 | 8,681 | 3,240 | 1,985,107 | 228.67 | 188,156 |
| 06.... | 21,045,316 | 1,061,076 | 0.050 | 13,928 | 5,198 | 3,601,021 | 258.54 | 187,639 |
| 07.... | 20,505,197 | 1,037,728 | 0.051 | 7,515 | 2,805 | 2,509,926 | 333.99 | 175,651 |
| 08.... | 9,289,376 | 393,050 | 0.042 | 4,155 | 1,551 | 1,096,615 | 263.92 | 134,119 |
| 09.... | 3,862,445 | 198,540 | 0.051 | 9,904 | 3,696 | 2,557,574 | 258.30 | 410,997 |
| 10.... | 24,323,829 | 1,438,609 | 0.059 | 10,009 | 3,736 | 3,320,699 | 331.77 | 1,717,584 |
| 11.... | 69,019,304 | 2,406,581 | 0.035 | 2,868 | 1,070 | 1,278,293 | 445.71 | 3,587,998 |
| 12.... | 309,766,030 | 6,033,231 | 0.019 | 3,692 | 1,378 | 1,716,630 | 464.96 | 2,777,853 |

| Year. | Potassium Salts. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Chlorate. | | | Chloride. | | | Chromate and Bichromate. | | | Nitrate. | | |
| | Lb. | Value. | Value per Lb. | Lb. | Value. | Value per Lb. | Lb. | Value. | Value per Lb. | Lb. | Value. | Value per Lb. |
| | | $ | $ | | $ | $ | | $ | $ | | $ | $ |
| 03.... | 468,042 | 19,308 | 0.041 | 169,337,673 | 2,550,478 | 0.015 | 41,229 | 2,784 | 0.067 | 13,835,668 | 367,721 | 0.026 |
| 04.... | 95,889 | 4,209 | 0.044 | 174,865,872 | 2,832,554 | 0.016 | 26,053 | 1,817 | 0.069 | 14,184,287 | 376,931 | 0.027 |
| 05.... | 42,510 | 2,876 | 0.067 | 214,207,064 | 3,326,748 | 0.016 | 59,650 | 4,225 | 0.070 | 9,911,534 | 304,596 | 0.027 |
| 06.... | 45,873 | 3,103 | 0.068 | 223,203,387 | 3,858,895 | 0.017 | 30,098 | 2,102 | 0.080 | 11,326,256 | 371,595 | 0.033 |
| 07.... | 12,980 | 959 | 0.074 | 252,303,441 | 4,175,353 | 0.017 | 18,171 | 1,307 | 0.072 | 18,291,890 | 574,977 | 0.031 |
| 08.... | 17,607 | 1,447 | 0.082 | 214,338,887 | 3,415,326 | 0.016 | 216,080 | 15,453 | 0.072 | 16,118,160 | 470,116 | 0.029 |
| 09.... | 22,425 | 1,837 | 0.082 | 298,854,649 | 4,780,106 | 0.016 | 640,623 | 31,798 | 0.050 | 14,883,849 | 437,690 | 0.027 |
| 10.... | 410,770 | 26,313 | 0.064 | 381,873,875 | 5,252,373 | 0.014 | 406,791 | 19,569 | 0.048 | 11,496,904 | 333,854 | 0.029 |
| 11.... | 27,856 | 2,450 | 0.088 | 509,119,193 | 7,651,684 | 0.015 | 22,408 | 2,159 | 0 096 | 7,945,747 | 265,061 | 0.038 |
| 12.... | 99,919 | 6,787 | 0.068 | 482,265,665 | 7,229,109 | 0.015 | 32,913 | 3,085 | 0.094 | 6,794,196 | 218,510 | 0.032 |

| Year | Potassium Salts. All Other. (g) | | Precious Stones. | | | Pyrites. (i) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Lb. | Value. | Uncut. | Cut, not Set. | Jewelry. | Long Tons. | Metric Tons. | Value. | Value per L. T. |
| 3. | 70,205,850 | $1,593,380 | $10,374,877 | $15,428,819 | $954,456 | 427,319 | 434,156 | $1,636,450 | $3.83 |
| 4. | 74,720,241 | 1,678,699 | 10,316,615 | 16,934,090 | 803,952 | 413,585 | 420,202 | 1,533,564 | 3.73 |
| 5. | 82,935,632 | 1,891,081 | 10,206,350 | 26,699,670 | 801,566 | 515,722 | 520,926 | 1,780,800 | 3.47 |
| 6. | 30,302,735 | 763,513 | 11,937,542 | 32,201,949 | 988,766 | 597,347 | 606,903 | 2,138,746 | 3.58 |
| 7. | 91,299,496 | 2,220,685 | 8,740,278 | 23,706,975 | 1,069,373 | 256,479 | 666,981 | 2,637,485 | 4.01 |
| 8. | 69,382,278 | 1,721,626 | 2,367,189 | 11,660,442 | 720,502 | 668,115 | 678,804 | 2,624,339 | 3.93 |
| 9. | 100,180,417 | 2,445,526 | 9,230,287 | 34,340,269 | 1,267,457 | 692,385 | 703,498 | 2,428,638 | 3.51 |
| 0. | 116,820,873 | 2,777,396 | 9,426,647 | 32,424,471 | 1,907,148 | 806,590 | 819,495 | 2,773,627 | 3.46 |
| 1. | 155,140,643 | 3,909,361 | 9,963,393 | 30,224,826 | 1,470,167 | 1,001,944 | 1,018,025 | 3,788,632 | 3.78 |
| 2. | 131,049,932 | 3,185,098 | 9,979,582 | 26,218,261 | 939,288 | 964,478 | 979,958 | 3,860,738 | 3.88 |

| Year. | Salt. | | | | Silver. | | Sodium Nitrate. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Short Tons. | Metric Tons. | Value. | Value per Sh. T. | In Coin and Bullion. | In Ore. | Long Tons. | Metric Tons. | Value. | Value per L. T. |
| 1903.. | 157,201 | 142,494 | $489,179 | $ 3.11 | $7,935,844 | $16,038,664 | 272,947 | 277,314 | $8,700,806 | $31.88 |
| 1904.. | 167,295 | 151,810 | 515,822 | 3.08 | 11,865,805 | 14,221,237 | 228,012 | 231,660 | 9,333,613 | 32.41 |
| 1905.. | 158,449 | 143,783 | 491,079 | 3.10 | 16,472,911 | 19,466,224 | 321,231 | 326,371 | 11,206,548 | 34.89 |
| 1906.. | 170,505 | 154,648 | 502,583 | 2.95 | 20,402,738 | 23,825,103 | 372,222 | 378,178 | 14,115,206 | 37.92 |
| 1907.. | 153,435 | 139,166 | 452,227 | 2.95 | 17,652,679 | 28,259,681 | 364,610 | 370,444 | 14,844,675 | 40.71 |
| 1908.. | 156,608 | 142,043 | 440,484 | 2.81 | 14,169,524 | 28,054,606 | 310,713 | 315,684 | 11,385,393 | 36.68 |
| 1909.. | 158,487 | 143,777 | 447,983 | 2.83 | 15,728,756 | 30,458,946 | 428,429 | ..... | 13,608,195 | 31.43 |
| 1910.. | 142,549 | 129,320 | 388,015 | 2.72 | 15,913,668 | 29,964,500 | 529,172 | 605,938 | 16,601,328 | 31.37 |
| 1911.. | 137,759 | 124,974 | 378,083 | 2.74 | 16,351,154 | 27,395,417 | 544,878 | 553,623 | 16,814,256 | 30.86 |
| 1912.. | 136,391 | 123,733 | 361,664 | 2.65 | 24,053,983 | 24,347,103 | 486,352 | 494,158 | 16,658,404 | 34.25 |

| Year. | Sodium Hydroxide (Caustic). | | | Soda Ash and Carbonate. | | | All other Sodium Salts. | |
|---|---|---|---|---|---|---|---|---|
| | Lb. | Value. | Value. per Lb. | Lb. | Value. | Value per Lb. | Lb. | Value. |
| 1903.. | 2,970,426 | $73,647 | $0.025 | 25,313,370 | $228,041 | $0.009 | 14,272,646 | 268,738 |
| 1904.. | 2,570,984 | 64,405 | 0.025 | 23,631,832 | 205,496 | 0.009 | 10,399,711 | 281,527 |
| 1905.. | 2,245,789 | 56,515 | 0.025 | 15,754,979 | 146,812 | 0.009 | 11,257,629 | 247,413 |
| 1906.. | 1,209,053 | 35,262 | 0.022 | 6,800,288 | 71,013 | 0.010 | ..... | ..... |
| 1907.. | 1,297,070 | 37,894 | 0.029 | 6,198,136 | 66,521 | 0.011 | 8,481,979 | 258,262 |
| 1908.. | 874,813 | 26,079 | 0.029 | 3,515,933 | 38,372 | 0.011 | ..... | 296,777 |
| 1909.. | 942,982 | 29,771 | 0.032 | 153,928 | 3,543 | 0.023 | 13,805,869 | 350,396 |
| 1910.. | 2,973,522 | 70,901 | 0.027 | 314,396 | 4,269 | 0.014 | 35,895,668 | 406,643 |
| 1911.. | 990,562 | 34,281 | 0.035 | 3,214,129 | 36,252 | 0.011 | 22,202,439 | 303,934 |
| 1912.. | 884,204 | 29,461 | 0.033 | 3,393,354 | 39,912 | 0.012 | 7,332,392 | 232,808 |

| Year. | Sulphur. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Crude. | | | | Flowers. | | | Refined. | | |
| | Long Tons. | Metric Tons. | Value. | Value per L. T. | Long Tons. | Metric Tons. | Value. | Long Tons. | Metric Tons. | Value. |
| 1903.. | 188,888 | 191,910 | $1,649,756 | $19.32 | 1,854 | 1,883 | $52,680 | 189 | 192 | $7,254 |
| 1904.. | 128,885 | 130,947 | 2,463,779 | 19.12 | 1,332 | 1,353 | 39,133 | 204 | 207 | 9,776 |
| 1905.. | 83,201 | 84,532 | 1,522,005 | 18.29 | 572 | 581 | 16,037 | 778 | 709 | 19,960 |
| 1906.. | 72,404 | 73,562 | 1,282,873 | 17.72 | 1,100 | 1,118 | 29,565 | 709 | 720 | 17,928 |
| 1907.. | 20,399 | 20,725 | 355,944 | 17.45 | 1,458 | 1,481 | 41,216 | 606 | 616 | 14,589 |
| 1908.. | 20,118 | 20,441 | 318,577 | 15.83 | 793 | 804 | 22,562 | 692 | 700 | 17,227 |
| 1909.. | 26,914 | 27,346 | 458,954 | 17.05 | 770 | 782 | 23,084 | 966 | 982 | 26,021 |
| 1910.. | 28,647 | 29,105 | 495,988 | 17.31 | 915 | 930 | 30,180 | 990 | 1,004 | 25,869 |
| 1911.. | 24,250 | 24,639 | 436,725 | 18.01 | 3,891 | 3,953 | 83,491 | 986 | 1,002 | 24,906 |
| 1912.. | 26,885 | 27,317 | 494,778 | 18.40 | 1,310 | 1,331 | 39,126 | 1,665 | 1,692 | 40,933 |

| Year. | Talc. | | | | Tin. | | | |
|---|---|---|---|---|---|---|---|---|
| | Short Tons. | Metric Tons. | Value. | Value per Sh. T. | Lb. | Metric Tons. | Value. | Value per Lb. |
| 1903... | 1,790 | 1,623 | $19,635 | $11.00 | 83,133,847 | 37,702 | $22,265,367 | $0.268 |
| 1904... | 3,268 | 2,964 | 36,370 | 11.13 | 83,168,657 | 37,718 | 22,356,896 | 0.270 |
| 1905... | 4,000 | 3,630 | 48,225 | 12.06 | 89,227,698 | 40,507 | 26,316,023 | 0.294 |
| 1906... | 5,643 | 5,118 | 67,818 | 12.02 | 101,027,188 | 45,816 | 37,446,508 | 0.371 |
| 1907... | 10,060 | 10,221 | 126,391 | 12.56 | 82,548,838 | 37,436 | 32,075,091 | 0.389 |
| 1908... | 7,429 | 6,738 | 97,296 | 13.08 | 82,503,190 | 37,433 | 23,932,560 | 0.290 |
| 1909... | 8,377 | 7,599 | 102,964 | 12.29 | 95,350,020 | 43,250 | 27,559,937 | 0.289 |
| 1910... | 8,378 | 7,560 | 106,451 | 12.72 | 105,137,740 | 47,703 | 33,921,449 | 0.322 |
| 1911... | 7,113 | 6,453 | 88,050 | 12.38 | 106,936,872 | 48,506 | 43,390,639 | 0.406 |
| 1912... | 10,817 | 9,813 | 121,541 | 11.24 | 116,003,385 | 52,619 | 50,371,102 | 0.434 |

| Year. | Zinc. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Blocks, Pigs and Old. | | | | Oxide. (*j*) | | Sulphide. | | Mfres. |
| | Lb. | Metric Tons. | Value. | Value, per Lb. | Lb. | Value. | Lb. | Value. | Value. |
| 03 .... | 728,614 | 330 | $30,900 | 0.042 | $3,653,076 | $188,495 | 1,229,806 | $33,077 | 18,938 |
| 04 .... | 933,474 | 423 | 44,455 | 0.048 | 2,809,905 | 165,110 | 1,228,875 | 31,382 | 11,918 |
| 05 .... | 1,042,081 | 473 | 51,052 | 0.048 | 3,779,311 | 196,220 | 1,235,360 | 33,308 | 12,390 |
| 06 .... | 4,407,481 | 1,999 | 253,310 | 0.057 | 4,494,014 | 288,065 | 1,286,469 | 40,112 | 17,385 |
| 07 .... | 3,555,890 | 1,613 | 210,322 | 0.059 | 5,311,318 | 323,551 | 1,570,073 | 51,435 | 16,282 |
| 08 .... | 1,762,627 | 799 | 85,885 | 0.049 | 4,635,101 | 262,876 | 1,048,109 | 46,733 | 7,474 |
| 09 .... | 19,340,029 | 8,772 | 826,588 | 0.043 | 6,654,352 | 397,084 | 1,263,316 | 44,873 | 19,176 |
| 10 .... | 6,904,389 | 3,133 | 289,689 | 0.042 | 6,470,097 | 391,670 | 3,726,135 | 99,954 | 27,475 |
| 11 .... | 3,275,340 | 1,486 | 170,634 | 0.052 | 5,561,016 | 357,466 | 6,355,312 | 166,199 | 124,983 |
| 12 .... | 22,229,831 | 10,083 | 1,280,426 | 0.058 | 5,875,057 | 386,153 | 5,904,475 | 153,303 | 293,089 |

(*a*) From Summary of Commerce and Finance of the United States. (*b*) Includes arsenic sulphide. (*c*) Barrels of 0 lb. (*e*) Not including iron ore. (*f*) Not reported. (*g*) Includes pig and old. (*h*) Includes nickel oxide, alloys which nickel is the principal constituent and manufactures of nickel. (*i*) Containing more than 25 per cent. sulphur, Includes white pigments containing zinc but not lead, dry and in oil. (*m*) Includes bars of steel and steel forms t elsewhere specified. The high value is due to the value of "high-speed" steel. (*n*) Crude. (*o*) Crude, scrap and loys in which aluminum is chief component. (*p*) Crude and refined. (*q*) Also included in all other salts. (*q*) Soda h only. (*r*) Antimony contents of ores and regulus and metal. (*s*) Not kaimit.

EXPORTS OF DOMESTIC PRODUCTS. (*a*)

| Year. | Aluminum and Mfrs. of. | Asbestos and Mfrs of. | Cement. | | | |
|---|---|---|---|---|---|---|
| | | | Bbl.(*i*) | Metric Tons. | Value. | Value per Bbl. |
| 903 | $157,187 | $158,360 | 285,463 | 51,748 | $433,984 | $1.52 |
| 904 | 166,876 | 223,096 | 774,940 | 140,898 | 1,104,086 | 1.42 |
| 905 | 290,777 | ..... | 1,016,236 | 185,345 | 1,387,706 | 1.37 |
| 906 | 364,251 | 259,760 | 583,299 | 105,811 | 944,886 | 1.62 |
| 907 | 304,938 | 200,371 | 900,550 | 163,360 | 1,450,841 | 1.61 |
| 908 | 330,092 | 296,890 | 846,785 | 153,638 | 1,249,229 | 1.47 |
| 909 | 567,375 | 322,523 | 1,056,922 | 191,764 | 1,417,534 | 1.34 |
| 910 | 949,215 | 348,716 | 2,475,957 | 449,314 | 3,477,981 | 1.40 |
| 911 | 1,158,603 | 448,395 | 3,135,409 | 568,886 | 4,632,215 | 1.48 |
| 912 | 1,347,621 | 625,328 | 4,215,532 | 764,861 | 6,160,341 | 1.46 |

| Year | Coal. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Anthracite. | | | | Bituminous. | | | | Coke. | |
| | Long Tons. | Metric Tons. | Value. | Value per L. T. | Long Tons. | Metric Tons. | Value. | Value per L.T. | Long Tons. | Value. |
| 1903 | 2,008,857 | 2,040,999 | $9,780,044 | 4.86 | 6,303,241 | 6,404,093 | $17,410,385 | $2.76 | 416,385 | $2,091,875 |
| 1904 | 2,228,392 | 2,264,046 | 11,077,570 | 4.97 | 6,345,126 | 6,446,648 | 17,160,538 | 2.74 | 523,090 | 2,311,401 |
| 1905 | 2,229,983 | 2,265,663 | 11,104,654 | 4.98 | 6,959,265 | 7,070,613 | 17,867,964 | 2.56 | 599,054 | 2,243,010 |
| 1906 | 2,216,969 | 2,252,441 | 10,896,200 | 4.91 | 7,704,850 | 7,828,128 | (*k*)19,787,459 | 2.57 | 765,190 | 2,753,551 |
| 1907 | 2,698,072 | 2,741,241 | 13,217,985 | 4.90 | (*m*)10,454,677 | 10,621,950 | (*m*)26,982,111 | 2.54 | 874,689 | 3,206,793 |
| 1908 | 2,752,358 | 2,796,394 | 13,524,595 | 4.92 | (*m*) 9,100,819 | 9,246,431 | (*m*)23,361,914 | 2.53 | 620,923 | 2,161,032 |
| 1909 | 2,842,714 | 2,888,340 | 14,141,468 | 4.97 | (*m*) 9,693,843 | 9,849,429 | (*m*)24,300,050 | 2.51 | 895,461 | 3,232,673 |
| 1910 | 3,021,627 | 3,070,124 | 14,785,387 | 4.89 | (*m*)10,784,239 | 10,957,326 | (*m*)26,685,405 | 2.47 | 879,073 | 3,053,293 |
| 1911 | 3,553,999 | 3,611,041 | 18,093,285 | 5.09 | 13,878,754 | 14,101,508 | 34,499,989 | 2.49 | 914,042 | 3,215,490 |
| 1912 | 3,688,789 | 3,747,994 | 19,425,263 | 5.27 | 14,459,978 | 14,692,061 | 36,817,633 | 2.55 | 814,800 | 3,002,742 |

| Year. | Copper. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | In Ore and Matte (*b*). | | | | Ingots, Bars, Plates and Old. | | | | Mfrs. | Total Except Ore. |
| | Long Tons. | Metric Tons. | Value. | Value per L. T. | Lb. | Metric Tons. | Value. | Value per Lb. | Value. | |
| 903 | 12,291 | 12,488 | $855,367 | $69.59 | 310,729,524 | 140,920 | 41,170,059 | $0.132 | $2,339,729 | $43,509,788 |
| 904 | 18,927 | 19,230 | 1,202,537 | 63.54 | 554,550,030 | 251,497 | 71,488,116 | 0.129 | 3,328,818 | 74,816,934 |
| 905 | 37,688 | 38,291 | 1,531,429 | 40.63 | 534,907,619 | 242,699 | 80,693,232 | 0.151 | 4,184,070 | 84,890,302 |
| 906 | 47,619 | 48,380 | 1,760,140 | 36.96 | 454,752,018 | 206,239 | 84,728,400 | 0.186 | 4,284,611 | 89,013,011 |
| 907 | 99,141 | 100,727 | 2,452,562 | 24.74 | 508,929,401 | 230,799 | 94,912,185 | 0.186 | 5,888,170 | 100,800,355 |
| 908 | 63,149 | 64,158 | 1,254,172 | 19.87 | 661,876,127 | 300,302 | 87,393,200 | 0.132 | 3,162,303 | 90,555,503 |
| 909 | 59,880 | 60,841 | 1,335,316 | 22.29 | 682,846,726 | 309,734 | 89,367,455 | 0.131 | 3,217,185 | 92,584,640 |
| 910 | 43,784 | 44,585 | 1,049,086 | 23.96 | 695,107,043 | 315,384 | 88,949,799 | 0.128 | 5,132,287 | 94,082,086 |
| 911 | 57,915 | 58,844 | 2,352,080 | 40.61 | 786,553,208 | 356,778 | 98,168,182 | 0.122 | 5,159,664 | 103,327,346 |
| 912 | 66,171 | 67,233 | 3,203,220 | 4,841 | 775,000,658 | 351,538 | 123,007,884 | 0.159 | 3,762,283 | 127,770,167 |

| Year. | Gold. | | Iron. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ore. | | | | Pig. | | | |
| | In Coin and Bullion. (c) | In Ore. (d) | Long Tons. | Metric Tons. | Value. | Value per L. T. | Long Tons. | Metric Tons. | Value. | Value per L. T. |
| 1903..... | $43,765,360 | $581,474 | 80,611 | 81,901 | $255,728 | $3.17 | 20,379 | 20,705 | $384,334 | $18.86 |
| 1904..... | 120,226,424 | 985,403 | 213,865 | 217,287 | 458,823 | 2.14 | 49,025 | 49,809 | 764,543 | 15.60 |
| 1905..... | 46,099,580 | 694,887 | 208,017 | 211,345 | 530,457 | 2.55 | 49,221 | 50,009 | 762,899 | 15.50 |
| 1906..... | 46,068,451 | 640,707 | 265,240 | 269,484 | 771,831 | 2.91 | 83,317 | 84,650 | 1,506,774 | 18.08 |
| 1907..... | 54,869,688 | 345,993 | 278,208 | 282,659 | 763,422 | 2.74 | 73,703 | 74,879 | 1,508,938 | 20.43 |
| 1908..... | 80,778,091 | 437,365 | 309,099 | 314,043 | 1,012,924 | 3.29 | 46,696 | 47,441 | 789,318 | 16.92 |
| 1909..... | 132,340,610 | 540,211 | 455,934 | 463,251 | 1,365,325 | 2.99 | 61,989 | 62,994 | 1,030,267 | 16.66 |
| 1910..... | 58,305,510 | 469,312 | 644,875 | 655,193 | 2,074,164 | 3.22 | 127,385 | 129,423 | 2,113,036 | 16.51 |
| 1911..... | 36,683,309 | 499,265 | 768,386 | 780,719 | 2,653,448 | 3.45 | 120,799 | 122,738 | 1,874,401 | 15.52 |
| 1912..... | 43,921,951 | 470,333 | 1,195,742 | 1,214,934 | 3,537,289 | 2.96 | 272,676 | 277,052 | 3,832,765 | 14.06 |

| Year. | Iron, Bar. | | | | Iron, Band, Hoop and Scroll. | | | Billets, Ingots and Blooms. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Long Tons. | Metric Tons. | Value. | Value per L. T. | Long Tons. | Metric Tons. | Value. | Long Tons. | Metric Tons. | Value. | Value per L. T. |
| 1903..... | 19,380 | 19,690 | $796,631 | $41.11 | 1,241 | 2,175 | $101,839 | 5,445 | 5,532 | $141,924 | $26.07 |
| 1904..... | 29,582 | 30,055 | 1,133,128 | 34.93 | 3,435 | 3,489 | 162,039 | 314,324 | 319,353 | 6,150,035 | 19.56 |
| 1905..... | 32,025 | 32,537 | 1,255,418 | 39.20 | 4,426 | 4,497 | 182,431 | 237,738 | 241,542 | 4,701,909 | 19.79 |
| 1906..... | 56,024 | 56,920 | 2,575,905 | 45.98 | 5,405 | 5,491 | 242,776 | 192,616 | 195,698 | 4,094,659 | 21.26 |
| 1907..... | 24,190 | 24,577 | 1,092,631 | 45.17 | 8,587 | 8,724 | 395,758 | 79,991 | 81,271 | 2,013,319 | 25.17 |
| 1908..... | 8,224 | 8,355 | 362,909 | 44.12 | 4,334 | 4,402 | 223,073 | 112,177 | 113,390 | 2,674,524 | 23.84 |
| 1909..... | 13,536 | 13,755 | 538,436 | 39.77 | 3,856 | 3,918 | 200,379 | 104,862 | 106,545 | 2,401,091 | 22.90 |
| 1910..... | 18,045 | 18,234 | 726,300 | 40.25 | (n) | (n) | (n) | 58,230 | 59,162 | 1,274,732 | 21.89 |
| 1911..... | 17,683 | 17,967 | 653,320 | 36.94 | 3,731 | 3,791 | 163,853 | 234,267 | 238,027 | 5,150,518 | 21.99 |
| 1912..... | 21,926 | 22,278 | 341,824 | 38.39 | 12,557 | 12,759 | 539,354 | 295,818 | 300,566 | 6,615,131 | 22.36 |

| Year. | Iron, Nails and Spikes, Cut. | | | | Iron, Nails and Spikes, All Other. | | | | Iron, Plates and Sheets. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lb. | Metric Tons. | Value | Value per Lb. | Lb. | Metric Tons. | Value. | Value per Lb. | Long Tons. | Met. Tons. | Value. |
| 1903 | 19,912,563 | 9,031 | $424,985 | $0.021 | 75,654,532 | 34,310 | $1,698,500 | $0.024 | 4,782 | 4,858 | $273,618 |
| 1904 | 20,772,049 | 9,422 | 416,389 | 0.020 | 80,279,746 | 36,403 | 1,949,908 | 0.024 | 4,728 | 4,804 | 247,694 |
| 1905 | 17,674,099 | 8,019 | 352,405 | 0.020 | 89,976,088 | 40,506 | 2,118,836 | 0.024 | 8,004 | 8,132 | 460,995 |
| 1906 | 16,951,893 | 7,688 | 340,526 | 0.020 | 116,310,428 | 52,747 | 2,731,021 | 0.024 | 17,054 | 17,327 | 1,139,526 |
| 1907 | 15,521,208 | 7,042 | 354,802 | 0.023 | 111,670,147 | 50,642 | 3,014,863 | 0.027 | 40,651 | 41,301 | 2,902,025 |
| 1908 | 15,721,898 | 7,133 | 364,202 | 0.023 | 71,427,124 | 32,407 | 1,813,784 | 0.025 | 44,100 | 44,805 | 2,985,538 |
| 1909 | 22,256,458 | 10,095 | 456,635 | 0.021 | 85,387,006 | 38,731 | 1,993,142 | 0.023 | 75,305 | 76,513 | 4,706,592 |
| 1910 | 18,208,116 | 8,261 | 361,838 | 0.020 | 118,881,375 | 53,939 | 2,693,753 | 0.023 | 102,534 | 104,175 | 6,412,458 |
| 1911 | 25,585,379 | 11,605 | 470,515 | 0.018 | 148,875,384 | 67,529 | 3,279,105 | 0.022 | 134,497 | 137,113 | 8,353,089 |
| 1912 | 20,856,790 | 9,461 | 359,962 | 0.017 | 186,336,457 | 84,522 | 3,976,571 | 0.021 | 194,165 | 197,281 | 11,844,767 |

| Year. | Steel, Sheets and Plates. | | | Iron Rails. | | | | Steel Rails. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Long Tons. | Metric Tons. | Value. | Long Tons. | Metric Tons. | Value. | Value per L. T. | Long Tons. | Metric Tons. | Value. | Value per L. T. |
| 1903 .. | 13,312 | 13,525 | $657,713 | 181 | 184 | $8,808 | $48.67 | 30,656 | 31,146 | $937,779 | $30.59 |
| 1904 .. | 50,477 | 51,278 | 2,064,241 | 1,405 | 1,427 | 23,870 | 17.00 | 414,845 | 421,482 | 10,661,222 | 25.72 |
| 1905 .. | 67,093 | 68,166 | 2,889,084 | *Nil.* | ..... | ..... | ..... | 295,023 | 299,473 | 7,310,029 | 24.78 |
| 1906 .. | 93,601 | 95,099 | 4,081,915 | *Nil.* | ..... | ..... | ..... | 328,036 | 333,285 | 8,903,411 | 27.14 |
| 1907 .. | 82,045 | 83,358 | 4,262,582 | *Nil.* | ..... | ..... | ..... | 338,906 | 344,328 | 10,411,072 | 30.72 |
| 1908 .. | 60,893 | 61,865 | 3,422,031 | *Nil.* | ..... | ..... | ..... | 196,510 | 199,654 | 6,021,549 | 30.62 |
| 1909 .. | 104,742 | 106,423 | 4,627,614 | *Nil.* | ..... | ..... | ..... | 299,540 | 304,533 | 8,519,793 | 28.44 |
| 1910 .. | 171,982 | 174,734 | 7,514,832 | *Nil.* | ..... | ..... | ..... | 353,180 | 358,831 | 10,162,522 | 28.77 |
| 1911 . | 237,428 | 241,239 | 9,800,215 | *Nil.* | ..... | ..... | ..... | 420,874 | 427,629 | 12,229,045 | 29.05 |
| 1912 . | 352,802 | 358,464 | 14,508,622 | *Nil.* | ..... | ..... | ..... | 446,473 | 453,639 | 13,053,774 | 29.24 |

| ear. | Structural Iron and Steel. | | | | Wire. | | | | Steel Wire Rods. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Long Tons. | Metric Tons. | Value. | Value per L.T. | Long Tons. | Metric Tons. | Value. | Value per L. T. | Long Tons. | Metric Tons. | Value. | Value per L. T. |
| 3 . | 30,641 | 31,131 | $1,788,556 | $58.37 | 108,521 | 110,258 | $5,528,726 | $50.94 | 22,360 | 22,718 | $713,718 | 31.92 |
| 4 . | 55,514 | 56,402 | 2,777,768 | 50.04 | 118,581 | 120,478 | 5,935,093 | 50.05 | 20,073 | 20,394 | 695,448 | 34.64 |
| 5 . | 84,234 | 85,582 | 4,357,186 | 51.73 | 142,601 | 144,883 | 7,061,442 | 49.52 | 6,514 | 6,618 | 277,651 | 42.62 |
| 6 . | 112,555 | 114,356 | 6,140,861 | 54.56 | 174,014 | 176,798 | 8,770,042 | 50.40 | 5,896 | 5,990 | 221,679 | 37.60 |
| 7 . | 138,442 | 140,657 | 7,784,618 | 56.23 | 161,228 | 163,808 | 9,164,829 | 56.84 | 10,653 | 10,823 | 465,757 | 43.72 |
| 8 . | 116,878 | 118,746 | 6,289,610 | 53.80 | 136,167 | 138,344 | 7,270,794 | 53.35 | 7,412 | 7,530 | 277,694 | 37.39 |
| 9 . | 90,830 | 92,288 | 4,488,197 | 49.42 | 149,341 | 151,738 | 7,836,564 | 52.49 | 20,142 | 20,465 | 635,409 | 31.56 |
| 0 . | 146,721 | 149,069 | 7,127,673 | 48.58 | 171,928 | 174,679 | 9,198,005 | 53.49 | 22,869 | 23,235 | 714,553 | 31.25 |
| 1 . | 223,493 | 227,080 | 10,270,977 | 45.96 | 229,762 | 233,452 | 11,637,596 | 50.65 | 22,641 | 23,003 | 659,066 | 29.10 |
| 2 . | 288,164 | 292,789 | 12,694,804 | 44.05 | 244,711 | 248,639 | 11,536,442 | 47.14 | 65,023 | 66,067 | 1,898,986 | 29.20 |

| ear. | Lead and Mfres. of. | Nickel. (*e*) | Petroleum products. (In Thousands of Units.)* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Crude. | | | Naphtha. | | | Illuminating Oil. | | |
| | | | M Gals. | M Value. | Value per Gal. | M Gals. | M Value. | Value per Gal. | M Gals. | M Value. | Value. per Gal. |
| 3... | $491,362 | $703,550 | 126,512 | $6,782 | $0.054 | 12,973 | $1,519 | 0.118 | 691,837 | 51,356 | $0.074 |
| 4... | 616,126 | 2,130,933 | 111,176 | 6,351 | 0.057 | 24,989 | 2,322 | 0.093 | 761,358 | 58,384 | 0.077 |
| 5... | 511,609 | 2,894,700 | 126,185 | 6,086 | 0.048 | 28,420 | 2,215 | 0.078 | 881,450 | 54,901 | 0.062 |
| 6... | 600,057 | 3,493,643 | 148,045 | 7,731 | 0.052 | 27,545 | 2,488 | 0.090 | 878,284 | 54,858 | 0.063 |
| 7... | 686,096 | 2,845,663 | 126,306 | 6,334 | 0.050 | 34,625 | 3,676 | 0.106 | 905,924 | 59,635 | 0.066 |
| 8... | 599,640 | 3,297,988 | 149,190 | 6,520 | 0.044 | 43,887 | 4,543 | 0.103 | 1,129,005 | 75,988 | 0.067 |
| 9... | 509,542 | 4,101,976 | 186,305 | 6,568 | 0.035 | 68,759 | 5,800 | 0.084 | 1,046,401 | 67,814 | 0.065 |
| 0... | 614,158 | 4,704,088 | 180,111 | 5,404 | 0.029 | 100,695 | 8,407 | 0.083 | 940,247 | 55,642 | 0.059 |
| 1... | 680,419 | 8,283,777 | 201,843 | 6,165 | 0.030 | 137,295 | 11,483 | 0.084 | 1,112,295 | 61,055 | 0.055 |
| 2... | 651,459 | 8,515,332 | 188,711 | 6,770 | 0.036 | 186,000 | 20,459 | 0.110 | 1,026,138 | 62,084 | 0.061 |

| ear. | Petroleum Products. (In Thousands of Units.)* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Lubricating Oil. | | | Residue, Etc. (*g*) | | | Paraffin. | | | |
| | M Gals. | M Value. | Value per Gal. | M Gals. | M Value. | Value per Gal. | M Lb. | M Metric Tons. | M Value. | Value per Lb. |
| 3 ... | 95,622 | $12,690 | $0.133 | 9,753 | $282 | $0.029 | 204,120 | 92.6 | $9,596 | $0.047 |
| 4 ... | 89,738 | 12,389 | 0.138 | 34,904 | 1,174 | 0.034 | 174,582 | 79.2 | 8,273 | 0.047 |
| 5 ... | 113,730 | 14,312 | 0.126 | 70,728 | 2,128 | 0.030 | 160,836 | 73.0 | 7,873 | 0.049 |
| 6 ... | 151,269 | 18,690 | 0.124 | 64,645 | 1,971 | 0.030 | 173,504 | 72.9 | 8,463 | 0.049 |
| 7 ... | 152,029 | 19,210 | 0.126 | 75,775 | 2,528 | 0.033 | 207,504 | 94.1 | 10,209 | 0.049 |
| 8 ... | 147,769 | 18,971 | 0.128 | 77,552 | 2,793 | 0.036 | 141,667 | 64.2 | 6,923 | 0.049 |
| 9 ... | 161,640 | 20,076 | 0.124 | 107,999 | 3,640 | 0.034 | 181,328 | 82.6 | 7,609 | 0.042 |
| 0 ... | 163,832 | 20,291 | 0.125 | 117,605 | 3,732 | 0.032 | 199,913 | 90.7 | 7,329 | 0.037 |
| 1 ... | 183,320 | 23,337 | 0.127 | 133,979 | 3,882 | 0.029 | 214,018 | 97.1 | 7,048 | 0.033 |
| 2 ... | 216,393 | 28,297 | 0.031 | 266,237 | 6,599 | 0.025 | 294,591 | 133.6 | 9,603 | 0.033 |

| ear. | Crude Phosphates. | | | | Quicksilver. | | | Silver. | |
|---|---|---|---|---|---|---|---|---|---|
| | Long Tons. | Metric Tons. | Value. | Value per L.T. | Lb. | Metric Tons. | Value. | In Coin and Bullion (*c*) | In Ore (*d*) |
| 3.... | 785,259 | 797,823 | $6,109,230 | $7.78 | 1,344,615 | 610 | $719,119 | 40,531,095 | 79,247 |
| 4.... | 842,484 | 855,964 | 6,521,555 | 7.74 | 1,611,365 | 731 | 847,108 | 49,975,370 | 159,875 |
| 5.... | 934,940 | 949,899 | 7,465,592 | 7.91 | 1,009,446 | 458 | 497,470 | 54,133,721 | 3,379,381 |
| 6.... | 904,214 | 918,681 | 7,373,945 | 8.16 | 484,151 | 219 | 243,914 | 57,012,104 | 266,674 |
| 7.... | 1,018,212 | 1,034,503 | 8,387,176 | 8.24 | 384,913 | 174 | 192,094 | 61,202,024 | 423,842 |
| 8.... | 1,196,175 | 1,215,374 | 9,371,649 | 7.83 | 224,692 | 102 | 124,960 | 51,554,414 | 283,257 |
| 9.... | 1,020,556 | 1,036,936 | 7,644,368 | 7.49 | 510,241 | 231 | 266,243 | 56,876,292 | 716,017 |
| 0.... | 1,083,037 | 1,100,366 | 8,234,276 | 7.63 | 144,237 | 65 | 91,077 | 56,984,109 | 376,864 |
| 1.... | 1,246,577 | 1,266,585 | 9,235,388 | 7.41 | 21,841 | 10 | 13,995 | 65,470,010 | 194,636 |
| 2 ... | 1,206,520 | 1,225,885 | 8,996,456 | 7.46 | 23,283 | 11 | 13,360 | 66,346,486 | 137,752 |

| Year. | Zinc Ore. | | | | Zinc Pigs, Bars, Plates and Sheet. | | | |
|---|---|---|---|---|---|---|---|---|
| | Long Tons. | Metric Tons. | Value. | Value Per L.T. | Lb. | Metric Tons. | Value. | Value. per Lb. |
| 1903 | 35,188 | 35,751 | $987,000 | $28.05 | 3,041,911 | 1,380 | $ 163,379 | 0.053 |
| 1904 | 32,063 | 32,576 | 905,782 | 28.25 | 20,145,942 | 9,204 | 1,094,490 | 0.053 |
| 1905 | 27,630 | 28,072 | 848,451 | 30.71 | 11,031,815 | 5,005 | 682,254 | 0.062 |
| 1906 | 24,750 | 25,146 | 733,300 | 29.63 | 9,340,455 | 4,236 | 583,526 | 0.062 |
| 1907 | 18,171 | 18,462 | 579,490 | 31.89 | 1,126,753 | 511 | 75,194 | 0.067 |
| 1908 | 23,311 | 23,683 | 877,745 | 37.61 | 5,280,344 | 2,396 | 250,254 | 0.047 |
| 1909 | 11,121 | 11,299 | 412,300 | 37.01 | 5,131,360 | 2,328 | 263,010 | 0.051 |
| 1910 | 17,599 | 17,881 | 649,425 | 36.90 | 7,979,457 | 3,620 | 426,500 | 0.053 |
| 1911 | 16,322 | 16,584 | 642,884 | 39.39 | 13,744,212 | 6,234 | 810,099 | 0.059 |
| 1912 | 20,847 | 21,182 | 823,997 | 39.53 | 13,268,168 | 6,018 | 864,292 | $0.065 |

| Year. | Zinc Oxide. | | | |
|---|---|---|---|---|
| | Lb. | Metric Tons. | Value. | Value per Lb. |
| 1903 | 14,429,885 | 6,544 | $578,215 | $0.041 |
| 1904 | 16,313,826 | 7,399 | 628,494 | 0.039 |
| 1905 | 22,559,625 | 10,236 | 810,203 | 0.036 |
| 1906 | 31,156,616 | 14,129 | 1,149,297 | 0.037 |
| 1907 | 26,512,920 | 12,023 | 1,069,924 | 0.040 |
| 1908 | 24,016,254 | 10,893 | 845,070 | 0.035 |
| 1909 | 26,691,347 | 13,468 | 1,026,377 | 0.035 |
| 1910 | 26,333,993 | 11,949 | 943,968 | 0.036 |
| 1911 | 29,236,779 | 13,262 | 1,051,311 | 0.036 |
| 1912 | 34,128,163 | 15 480 | 1,247,702 | 0.037 |

## RE-EXPORTS OF FOREIGN PRODUCTS. (a)

| Year. | Antimony. | | | Antimony Ore. | | | Asphaltum, Crude. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Lb. | Metric Tons. | Value. | Short Tons. | Metric Tons. | Value. | Long Tons. | Metric Tons. | Value. |
| 1903 | 79,917 | 36.0 | $4,478 | *Nil.* | ..... | ..... | 1,605 | 1,631 | $13,894 |
| 1904 | 31,077 | 14.0 | 1,734 | 214 | 194.0 | 10,775 | 1,887 | 1,917 | 26,272 |
| 1905 | *Nil.* | ..... | ..... | *Nil.* | ..... | ..... | 1,081 | 1,098 | 18,190 |
| 1906 | 24,892 | 11.2 | 4,939 | *Nil.* | ..... | ..... | 1,765 | 1,793 | 22,324 |
| 1907 | 47,999 | 21.8 | 9,064 | 6 | 5 | 273 | 8,288 | 8,421 | 31,749 |
| 1908 | 1,763 | 0.8 | 125 | 4.8 | 4.3 | 663 | 4,262 | 4,290 | 21,419 |
| 1909 | 6,648 | 3.0 | 475 | 0.25 | 0.23 | 56 | 6,867 | 6,977 | 48,375 |
| 1910 | 339,685 | 154.1 | 20,392 | *Nil.* | ..... | ..... | 5,830 | 5,948 | 29,942 |
| 1911 | 160,844 | 73.0 | 9,737 | *Nil.* | ..... | ..... | 3,402 | 3,457 | 48,552 |
| 1912 | (c)50,684 | 23.0 | 2,766 | *Nil.* | ..... | ..... | 2,589 | 2,631 | 62,276 |

| Year. | Cement. | | | Chemicals. | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Salts of Potassium. (f) | | | Chloride of Lime. | | |
| | Bbl. (i) | Metric Tons. | Value. | Lb. | Kg. | Value. | Lb. | Kg. | Value. |
| 1903 | 25,362 | 4,601 | $32,156 | 1,299,905 | 589,637 | $33,264 | 836,411 | 379,696 | $7,609 |
| 1904 | 39,711 | 7,186 | 54,486 | 1,262,222 | 572,544 | 33,358 | 1,434 | 650 | 13 |
| 1905 | 31,874 | 5,782 | 40,583 | 3,053,191 | 1,386,149 | 83,652 | 100 | 102 | 3 |
| 1906 | 16,216 | 2,941 | 19,487 | 2,264,175 | 1,027,935 | 77,043 | *Nil.* | ..... | ..... |
| 1907 | 20,697 | 3,754 | 30,435 | 2,675,248 | 1,285,892 | 75.470 | *Nil.* | ..... | ..... |
| 1908 | 9,552 | 1,734 | 11,455 | 1,046,689 | 570,445 | 34,505 | 121,511 | 55,116 | 912 |
| 1909 | 4,198 | 762 | 6,312 | 2,332,386 | 1,058,251 | 66,352 | 13,964 | 6,334 | 292 |
| 1910 | 17,914 | 3,251 | 24,878 | 2,187,787 | 922,645 | 60,648 | 496 | 225 | 6 |
| 1911 | 8,529 | 1,547 | 14,095 | 2,731,792 | 1,239,133 | 67,297 | 17,804 | 8,076 | 241 |
| 1912 | 4,356 | 790 | 8,419 | 4,932,143 | 2,237,205 | 103,425 | 400 | 181 | 8 |

**Chemicals. (*Continued.*)**

| Year. | Nitrate of Sodium. | | | Caustic Soda. | | | Soda Ash and Carbonate. | | | Sodium Salts, All Other. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Long Tons. | Metric Tons. | Value. | Lb. | Kg. | Value. | Lb. | Kg. | Value. | Lb. | Kg. | Value. |
| 1903.. | 4,417 | 4,488 | $184,657 | 1,116,354 | 506,378 | $23,227 | 30,030 | 13,622 | $464 | 42,540 | 19,294 | $437 |
| 1904.. | 6,076 | 6,173 | 279,864 | 1,115,600 | 506,036 | 23,608 | 40,351 | 18,303 | 593 | 1,778,616 | 806,780 | 25,312 |
| 1905.. | 8,991 | 9,135 | 420,613 | 1,087,772 | 493,848 | 22,728 | 32,221 | 14,628 | 473 | 16,748 | 7,604 | 177 |
| 1906.. | 6,660 | 6,767 | 324,915 | (*l*) | ..... | ..... | 2,486 | 1,128 | 41 | 1,032,372 | 468,180 | 21,624 |
| 1907.. | 7,159 | 7,274 | 370,048 | (*l*) | ..... | ..... | 3,100 | 1,406 | 53 | 742,201 | 336,662 | 16,099 |
| 1908.. | 9,955 | 10,113 | 514,799 | (*l*) | ..... | ..... | 4,645 | 2,104 | 77 | 834,207 | 378,726 | 18,255 |
| 1909.. | 8,233 | 8,365 | 377,571 | (*l*) | ..... | ..... | (*l*) | ..... | .... | 1,053,410 | 477,816 | 21,777 |
| 1910.. | 5,784 | 5,878 | 250,550 | (*l*) | ..... | ..... | (*l*) | ..... | .... | 333,427 | 151,282 | 11,767 |
| 1911.. | 6,787 | 6,896 | 269,274 | (*l*) | ..... | ..... | (*l*) | ..... | .... | 611,922 | 277,566 | 14,479 |
| 1912.. | 8,853 | 8,995 | 440,200 | (*l*) | ..... | ..... | (*l*) | ..... | .... | 431,407 | 195,685 | 9,416 |

| Year. | Coal, Bituminous. | | | Copper. | | | | | | Graphite. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ore and Matte. | | | Pigs, Bars, Ingots, Old and All Unmanufactured. | | | | |
| | Long. Tons. | Metric Tons. | Value. | Long Tons. | Metric Tons. | Value. | Lb. | Metric Tons. | Value. | Long Tons. | Value. |
| 1903.... | 88,468 | 89,883 | $453,613 | 5,750 | 5,232 | $852,726 | 2,093,103 | 949 | $261,413 | 63 | $4,223 |
| 1904.... | 7,250 | 7,366 | 21,910 | *Nil.* | .... | ..... | 1,088,672 | 494 | 140,695 | 8 | 455 |
| 1905.... | 3,945 | 4,008 | 10,974 | *Nil.* | .... | ..... | 1,718,584 | 780 | 272,945 | 5 | 91 |
| 1906.... | 2,541 | 2,582 | 13,062 | 71 | 72 | 29,791 | 1,567,782 | 711 | 309,605 | 3 | 362 |
| 1907.... | 1,947 | 1,978 | 12,199 | .... | .... | ..... | 995,555 | 451 | 199,828 | 1 | 41 |
| 1908.... | 4,759 | 4,832 | 16,313 | 2 | 2 | 50 | 718,541 | 326 | 93,148 | .... | ..... |
| 1909.... | 3,128 | 3,178 | 8,532 | 434 | 441 | 5,600 | 1,058,528 | 480 | 135,952 | 16 | 976 |
| 1910.... | 3,734 | 3,894 | 13,761 | *Nil.* | .... | ..... | 55,857 | 25 | 6,443 | 34 | 3,192 |
| 1911.... | 3,718 | 3,778 | 10,296 | *Nil.* | .... | ..... | 200 | 0.1 | 52 | *Nil.* | ..... |
| 1912.... | 982 | 998 | 6,574 | *Nil.* | .... | ..... | 1,020 | 0.5 | 132 | *Nil.* | ..... |

**Iron and Steel.**

| Year. | Pig Iron. | | | Scrap. | | | Bar Iron. | | | Rails. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Long Tons. | Metric Tons. | Value. | Long Tons. | Metric Tons. | Value. | Long Tons. | Metric Tons. | Value. | Long Tons. | Metric Tons. | Value |
| 1903..... | 1,863 | 1,893 | $33,996 | 262 | 266 | $2,862 | 16 | 16 | $2,108 | 739 | 751 | $17,560 |
| 1904..... | 1,646 | 1,672 | 25,910 | 190 | 193 | 2,367 | 7 | 7 | 765 | 96 | 98 | 2,305 |
| 1905..... | 1,010 | 1,026 | 29,047 | 4,270 | 4,338 | 80,623 | 22 | 22 | 2,556 | 31 | 31 | 1,132 |
| 1906..... | 6,750 | 6,858 | 236,957 | 5,111 | 5,193 | 101,886 | 61 | 62 | 7,207 | *Nil.* | .... | ..... |
| 1907..... | 2,921 | 2,968 | 86,420 | 157 | 160 | 3,378 | 38 | 39 | 3,959 | *Nil.* | .... | ..... |
| 1908..... | 1,827 | 1,855 | 52,079 | 288 | 293 | 3,597 | 26 | 26 | 1,271 | *Nil.* | .... | ..... |
| 1909..... | 720 | 732 | 25,936 | .... | .... | ..... | 20 | 20 | 1,500 | *Nil.* | .... | ..... |
| 1910..... | 579 | 588 | 20,706 | .... | .... | ..... | 9 | 9 | 356 | *Nil.* | .... | ..... |
| 1911..... | 1,837 | 1,866 | 73,987 | 100 | 102 | 1,373 | 12 | 12 | 635 | *Nil.* | .... | ..... |
| 1912..... | 5,087 | 5,169 | 130.107 | 198 | 201 | 3,788 | 25 | 25 | 1,176 | *Nil.* | .... | ..... |

| Year. | Iron and Steel. (Continued.) | | | | | | | | | Lead and Mfrs. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Steel, Ingots, Blooms, Etc. | | | Sheets, Plates, Rods, Wire. | | | Tin and Terne Plates, Taggers Tin. | | | |
| | Long Tons. | Metric Tons. | Value. | Long Tons. | Metric Tons. | Value. | Long Tons. | Metric Tons. | Value. | |
| 1903..... | 60 | 61 | $5,316 | 55 | 56 | $5,532 | 2 | 2 | $184 | $2,917,957 |
| 1904..... | 40 | 41 | 6,208 | 108 | 110 | 6,482 | 81 | 82 | 5,306 | 2,880,907 |
| 1905..... | 86 | 87 | 15,570 | 161 | 164 | 8,019 | 26 | 26 | 3,014 | 2,441,196 |
| 1906..... | 196 | 199 | 14,104 | 318 | 323 | 27,631 | 0.4 | 0.4 | 28 | 2,307,345 |
| 1907..... | 292 | 297 | 25,974 | 14 | 14 | 1,220 | 42.2 | 42.9 | 1,813 | 2,416,082 |
| 1908..... | 33 | 34 | 9,822 | 66 | 69 | 3,441 | 4.7 | 4.7 | 351 | 3,101,953 |
| 1909..... | 60 | 61 | 10,389 | 42 | 43 | 2,630 | 14 | 14 | 6,273 | 3,139,908 |
| 1910..... | 121 | 123 | 24,867 | 96 | 98 | 6,122 | ..... | ..... | ..... | 2,511,830 |
| 1911..... | 108 | 110 | 19,721 | ..... | ..... | 34,177 | ..... | ..... | ..... | 4,067,574 |
| 1912..... | 470 | 478 | 57,743 | 58 | 59 | 6,786 | 175 | 178 | 15,886 | 2,698,115 |

| Year. | Salt. | | | Sulphur—Crude. | | | Tin in Blocks, Pig and Granulated. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Lb. | Metric Tons. | Value. | Long Tons. | Metric Tons. | Value. | Long Tons. | Metric Tons. | Value. |
| 1902..... | 2,310,759 | 1,048 | $4,544 | 1,253 | 1,273 | $28,024 | 479 | 486 | $286,897 |
| 1903..... | 7,804,215 | 3,585 | 26,636 | 967 | 982 | 22,658 | 512 | 520 | 317,805 |
| 1904..... | 2,089,234 | 948 | 2,814 | 2,493 | 2,533 | 58,887 | 519 | 527 | 322,234 |
| 1905..... | 611,912 | 278 | 893 | 1,713 | 1,741 | 36,858 | 557 | 567 | 375,763 |
| 1906..... | 1,462,413 | 663 | 1,129 | 403 | 409 | 8,475 | 807 | 820 | 650,411 |
| 1907..... | 1,166,049 | 529 | 1,686 | 301 | 306 | 5,759 | 562 | 571 | 492,415 |
| 1908..... | 2,525,945 | 1,146 | 9,352 | 380 | 386 | 8,500 | 244 | 248 | 156,761 |
| 1909..... | 1,617,705 | 734 | 1,700 | 16 | 16 | 284 | 441 | 448 | 294,649 |
| 1910..... | 2,124,983 | 964 | 2,173 | 5 | 5 | 145 | 620 | 630 | 467,526 |
| 1911..... | 449,025 | 204 | 646 | *Nil.* | ..... | ..... | 1,010 | 1,027 | 958,481 |
| 1912..... | 73,551 | 33 | 105 | 1,015 | 1,031 | 20,314 | 588 | 597 | 591,729 |

* For convenience in tabulating, the quantities of all petroleum products and their gross values have been divided by 1000.

(*a*) From Summary of Commerce and Finance of the United States. (*c*) Total exports of coin and bullion: that is, includes both foreign and domestic. (*d*) Only approximately correct. The Bureau of Statistics reports only the value of silver ores exported, but a much larger amount of silver leaves the country in copper matte, which is classified as copper ore, and no record is kept of its silver contents. The gold in copper matte exported is not included in the exports of gold given in the above table. These figures include ore of both domestic and foreign origin. (*e*) Includes nickel oxide and nickel matte. (*f*) Includes chlorate, chloride, nitrate and all other salts of potassium. (*g*) Reported in barrels, but calculated to gallons, on a basis of 42 gallons to the barrel. (*i*) Barrel of 400 lb. (*l*) Included in all other salts of soda (*m*) Does not include coal used for fuel on vessels for foreign trade. (*n*) Included in other manufactures. (*o*) Antimony contents of regulus, etc.

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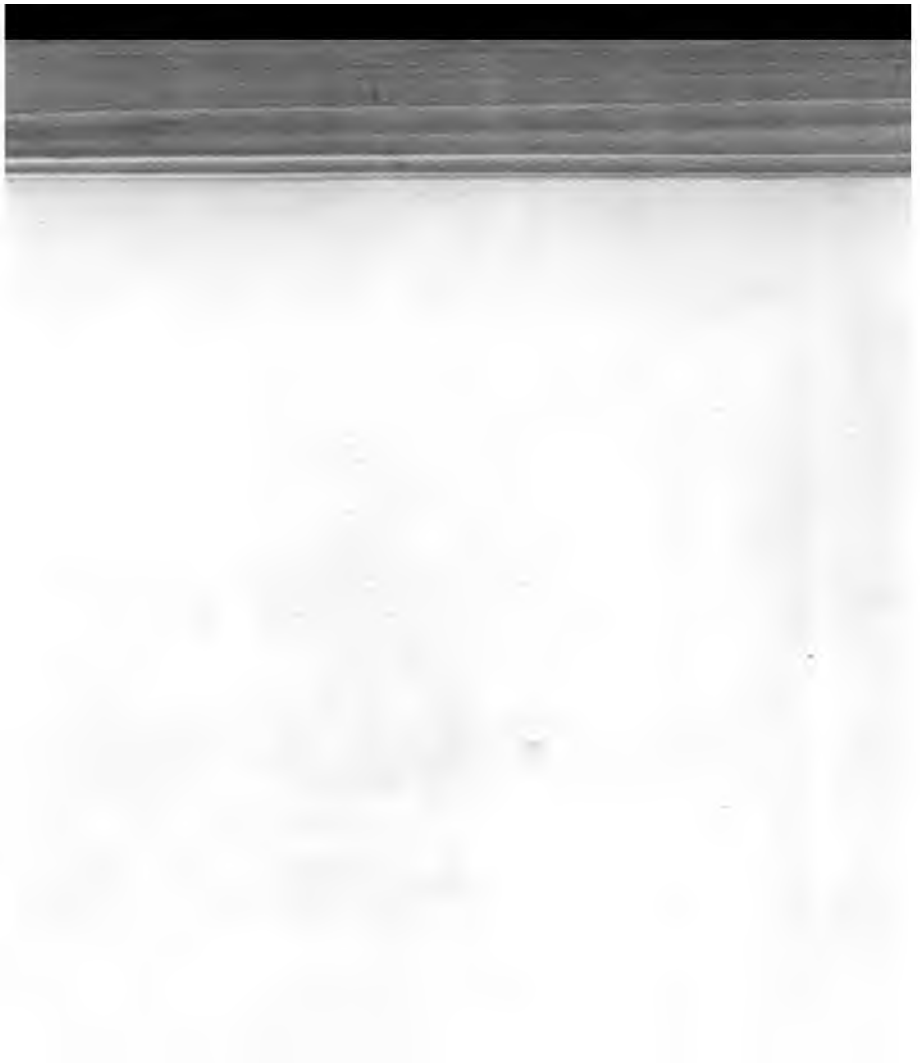

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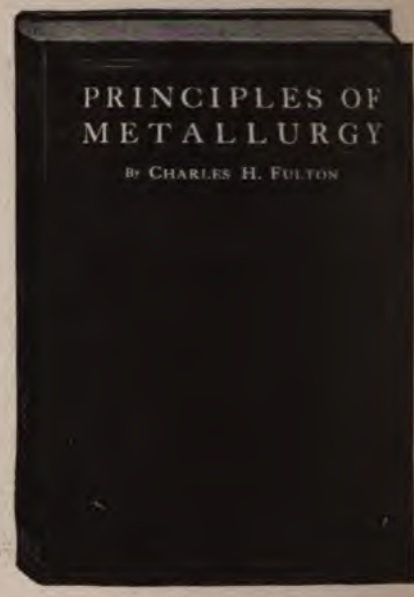


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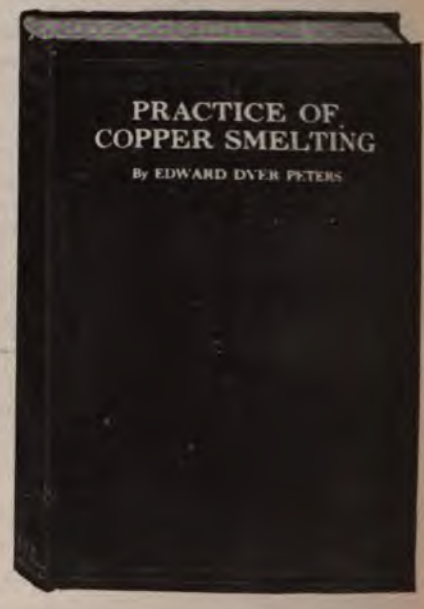


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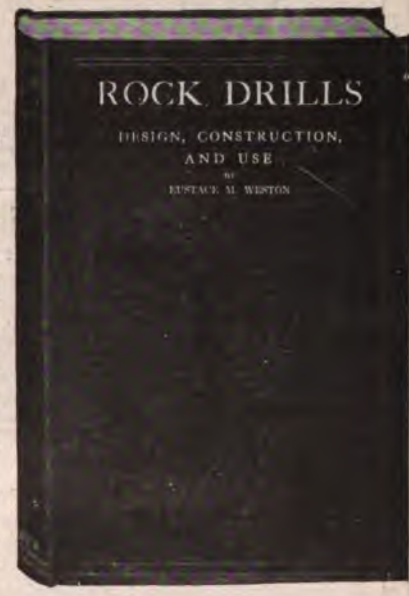


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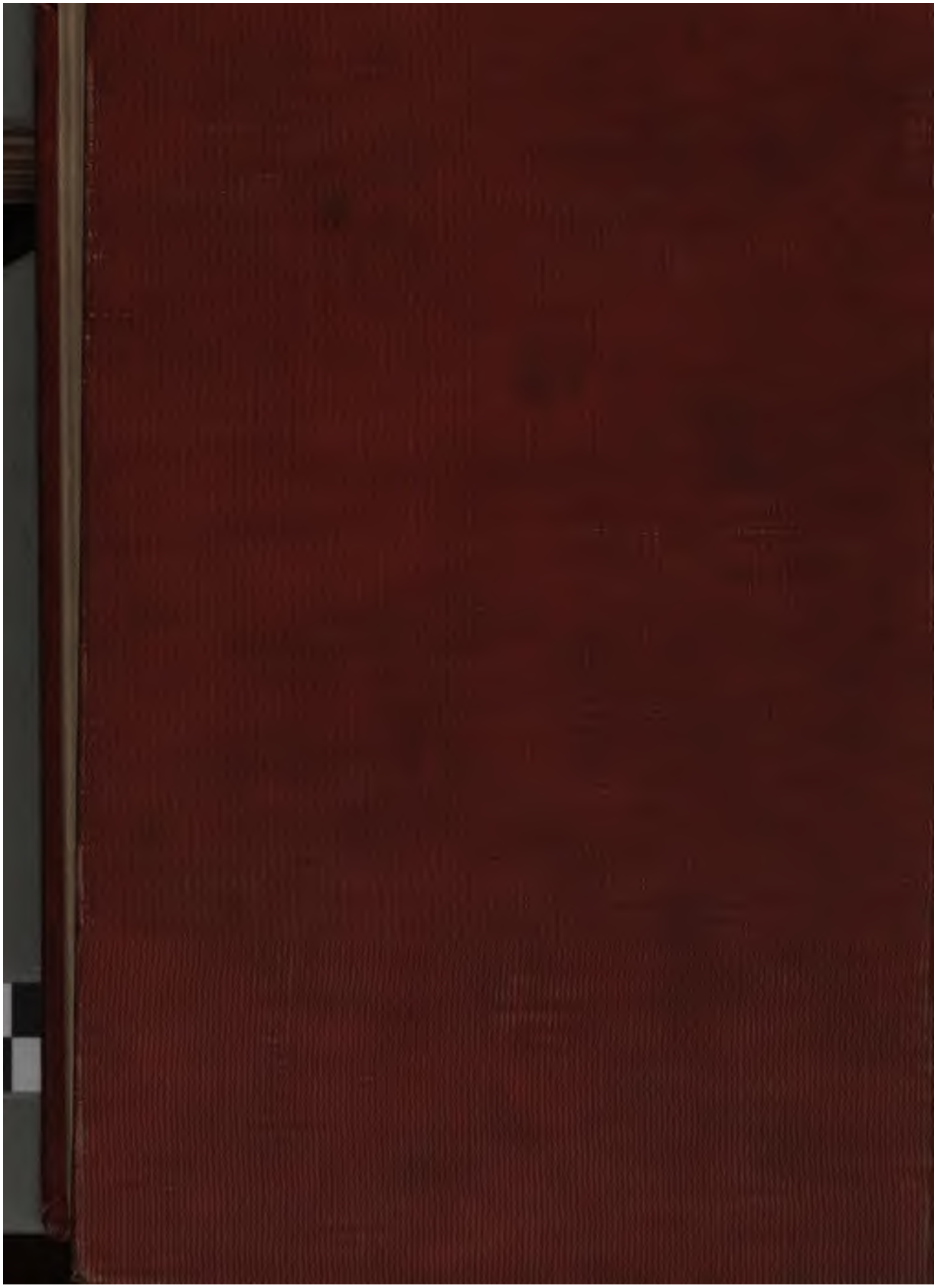
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